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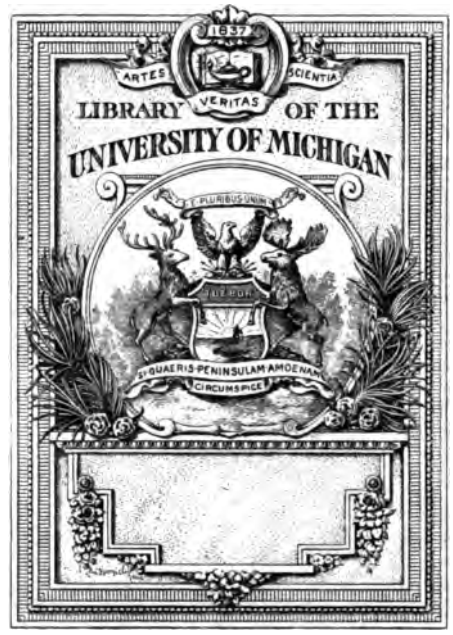

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60TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { DOCUMENT No. 781.

TENNESSEE RIVER FROM ELK RIVER SHOALS TO FLORENCE RAILWAY BRIDGE IN ALABAMA.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING,

WITH A LETTER FROM THE ACTING CHIEF OF ENGINEERS, REPORT OF EXAMINATION OF TENNESSEE RIVER FROM HEAD OF ELK RIVER SHOALS TO THE FLORENCE RAILWAY BRIDGE, IN ALABAMA, WITH A VIEW TO IMPROVEMENT BY PRIVATE OR CORPORATE AGENCY IN CONJUNCTION WITH THE DEVELOPMENT OF WATER POWER.

MARCH 12, 1908.—Referred to the Committee on Rivers and Harbors and ordered to be printed with accompanying illustrations.

WAR DEPARTMENT,
Washington, March 12, 1908.

SIR: I have the honor to transmit herewith a letter from the Acting Chief of Engineers, U. S. Army, dated 10th instant, together with copy of a report of a Board of Engineers, dated November 7, 1907, upon an examination of the Tennessee River from the head of Elk River shoals to the Florence Railway bridge, in the State of Alabama, and upon all plans which have been submitted by private or corporate agencies with a view to the improvement of the above-described stretch of said river, made in compliance with the provisions of an item contained in the river and harbor act of March 2, 1907.

Very respectfully,

WM. H. TAFT,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, March 10, 1908.

SIR: I have the honor to submit herewith for transmission to Congress a report, dated November 7, 1907, by the Board of Engineers

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appointed by the Secretary of War, in pursuance of the following provision in the river and harbor act of March 2, 1907:

The Secretary of War may appoint a Board of Engineers whose duty it shall be to examine the present condition of the United States Canal and the Tennessee River from the head of Elk River shoals to the Florence Railway bridge, in the State of Alabama, with a view to permitting the improvement of the above-described stretch of said river by private or corporate agency in conjunction with the development of water power by means of not more than three locks and dams; and the said Board may examine any plans presented by such agency and shall report whether the same, if constructed, can, without injury to navigation, or with advantage thereto, be used to develop water power, and what portion, if any, of the expense of the work should be borne by the United States.

2. The Board has given the subject very careful consideration and its comprehensive and instructive report covers the various questions set forth in the aforesaid provisions of the act.

3. The first question presented is as to permitting the improvement by private parties of the Tennessee River between the head of Elk River shoals and the Florence Railway bridge in conjunction with the development of water power by means of not more than three locks and dams.

4. The Board concludes that it would not be to the advantage of navigation to attempt the improvement of the entire section by not to exceed three locks and dams, but a portion of it can be so improved, and the entire stretch could probably be so improved by four locks and dams, the lower one of comparatively small lift and the upper three with approximately 40-foot lifts for use both for purposes of water power and navigation. In this the Chief of Engineers concurs.

5. The second question relates to the plans presented for the consideration of the Board. Two plans were presented, one of which, for reasons given, it states should not have favorable consideration by the Government. The other plan, that of the Muscle Shoals Hydro-Electric Power Company, provides for the construction of three dams covering the greater portion of the section of the river under consideration, giving 6 feet over miter sills at low water, the locks to be of same horizontal dimensions as those of the existing Muscle Shoals Canal. These dams would drown out the existing Muscle shoals and Elk River shoals canals, but it is the opinion of the Board that if properly built and maintained the substitution would benefit navigation and could at the same time be utilized for water power purposes. The Board is, however, of the opinion that the plans presented do not provide sufficient strength to give such assurance of safety as to guarantee against the disaster which would result from the failure of any of these structures. And it appears that such plans must include four dams to cover the section of the river under discussion.

6. The third question relates to the matter of cooperation as to expense, and asks what portion, if any, of the expense of the work should be borne by the United States. The Board expresses the opinion that no portion of the expense should be borne by the United States unless the plans of the company desiring permission to build the works shall be so modified as to give absolute assurance of safety from disastrous failure and provide locks of such dimensions as should conform to what Congress may decide to be sufficient for the

Tennessee River for all future time. When plans are so modified, the Board is of the opinion that the United States might bear such portion of original construction as would be measured by the cost of completing the canal system between the head of Pattons Island and the head of Elk River shoals, the proposed work replacing the unexecuted portion of the approved Government project between these points. Such portion of the expense being practically the same as that of constructing the locks in the water power dams, the Board suggests that the undertaking of the lock construction by the United States might be a most satisfactory division of the work. Such recommendation of the Board should be modified to include the four dams required, and the extension of the section of river from the head of Pattons Island to the Florence Railway bridge.

7. The question of cooperation on the part of the Government is the most complicated of the propositions presented to the Board. In drawing conclusions as to such matter of contribution in this special case the following points are worthy of consideration:

The existing project for improving navigation in this section of the Tennessee River provides for lateral canals and open-river channel improvement, contemplating 5-foot navigation. The Elk River and Muscle shoals canals constitute part of such project, but much work remains to be done to give a satisfactory navigation over the section being considered.

The completion of this project will satisfy all existing requirements of commerce and continue to do so until such time as the general improvement of the Tennessee River on a scale commensurate with a future possible through traffic, including coal, is determined on or provided for. All the traffic which can now reach this isolated part of the river can be accommodated by the Muscle Shoals Canal and the present projected improvements connected therewith. The proposed improvement on the main river, which would require fewer locks and furnish long deep pools, would materially improve navigation facilities over this stretch of the river and would furnish an important link in a general extended project for the entire river. But until such extended project is adopted such an improvement for a limited section would not appear to be so necessary as to justify the Government in adopting at this time or going to any greater expense in connection with it under any conditions than is represented by such amounts as the Government anticipates expending for completing the existing project, taking into consideration possibly the construction [illegible] required for an extended complete project. The construction of the proposed dams in the main river would [illegible] and necessitate the use of [illegible] conditions it is not [illegible] more than a [illegible] destroyed. If, in the [illegible] requiring greater [illegible] and other items of [illegible] sider the pools [illegible] extended project and [illegible] United States.

8. The preceding [illegible] original con[illegible]

by the Government of possibly $5,000,000, which amount must be provided or authorized before action, involving such cooperation, can be favorably acted upon. That is, provision must be made for completing any one of the proposed dams with necessary locks before the portion of the present canals to be drowned out can be abandoned.

9. The Board recites that any favorable action by the Government in this matter should include similar conditions to those found acceptable at Hales bar and other combined water power and navigation propositions; and also the conditions considered in the general dam act, so far as they can be made applicable, including a reversion of properties to the United States at the end of ninety-nine years. Whether any further return to the United States in connection with the uses of water in this case should have consideration is a matter for consideration by Congress.

10. Further consideration will be given to the details of this proposition in connection with a report on a bill, H. R. 12673, Sixtieth Congress, first session, "For the purpose of improving the navigation of the Tennessee River over the Elk River shoals, and the Big and Little Muscle shoals, and for other purposes."

Very respectfully,

SMITH S. LEACH,
Acting Chief of Engineers.

The SECRETARY OF WAR.

REPORT OF A BOARD OF ENGINEERS OF EXAMINATION OF THE PRESENT CONDITION OF THE UNITED STATES CANAL AND THE TENNESSEE RIVER FROM THE HEAD OF ELK RIVER SHOALS TO THE FLORENCE RAILWAY BRIDGE, ALA., WITH A VIEW TO IMPROVEMENT BY PRIVATE OR CORPORATE AGENCY IN CONJUNCTION WITH THE DEVELOPMENT OF WATER POWER.

CHATTANOOGA, TENN., *November 7, 1907.*

GENERAL: 1. The Board of Engineer officers appointed by Special Order No. 8, War Department, Office of the Chief of Engineers, March 9, 1907, having completed the work assigned to it, now has the honor to submit the following report, viz:

2. The law authorizing the appointment of this Board is found in the river and harbor act of March 2, 1907, and provides that the Secretary of War may appoint a Board of Engineers, whose duty it shall be to examine the present condition of the United States canal and the Tennessee River from the head of the Elk River shoals to the Florence Railway bridge in the State of Alabama, with a view to permitting the improvement of the above-described stretch of river by private or corporate agency, in conjunction with the development of water power by means of not more than three locks and dams; and the said Board may examine any plans presented by such agency, and shall report whether the same, if constructed, can, without injury to navigation, or with advantage thereto, be used to develop water power and what portion, if any, of the expense of the work should be borne by the United States.

3. In compliance with the aforementioned law and order the Board has examined the Tennessee River from the head of Elk River shoals to the Florence Railway bridge, and has held public hearings at which all parties at interest were afforded an opportunity to be heard;

has examined all plans which have been submitted by private or corporate agencies, and has given much study to the problems presented.

4. The section of river to be considered extends from the head of Browns Island about 11 miles below Decatur, Ala., to the Florence Railway bridge, a length of about 38 miles, in which length the river has a fall of 131.2 feet. The river is generally broad and shallow and contains many islands, and its bed is of limestone rock. The fall is not uniformly distributed throughout the length in question; the greater portion of it being concentrated in a length of about 14 miles, nearly midway of the section, and constituting that portion locally known as "Big Muscle shoals." The remaining portions under consideration were susceptible, in their natural condition, of a certain navigation; although such navigation was not unattended with difficulty and danger. The Big Muscle shoals was entirely unnavigable. The necessity for improving this portion of the river was very early recognized, and the United States has made two separate efforts to overcome this great obstruction to navigation.

5. In the act of Congress of May 23, 1828, a grant was made to the State of Alabama of 400,000 acres of the public land, to be sold and the proceeds to be applied to the improvement of the navigation of the Muscle shoals and the Colbert shoals in the Tennessee River; and it was provided that the plan of improvement should embrace, if practicable, a connection with the navigation of Elk River. This trust was accepted by the State of Alabama; the lands were selected and gradually sold, but those who had the improvement in charge, being impressed by the desirability of overcoming at once the insurmountable parts of the obstruction to navigation, sought as early as 1831 the authority of Congress to limit their improvement to the Big Muscle shoals, and this was granted in an act of February 12, 1831, which permitted the commissioners of the State to contract for and construct that part of the canal around the Muscle shoals beginning at Campbells Ferry and running up the river to Lambs Ferry, before contracting for or completing the remaining portions.

6. The original plan of improvement was prepared by the officers of the United States and was signed by the President. It contemplated the construction of a lateral canal on the right bank of the river covering the entire section which the Board now has under consideration. The depth of the canal was to be 6 feet, its bottom width 42 feet, and the locks to be 120 feet long by 32 feet wide, with 6 feet of water on sills. This canal was completed by the State of Alabama so as to cover the length of Big Muscle shoals, but it left unimproved a length of river both above and below the canal wherein the navigation was difficult, dangerous, and often impracticable. As a result the canal was not used for commercial purposes. A few boats passed through it under stress of great necessity or advantage; but no provision was made for the maintenance of the canal, and as the authorized tolls proved insufficient to take care of it, it fell into decay and soon became entirely unserviceable. The timber portions of the locks rotted out, the banks were breached in many places, and trees grew up over the right of way.

7. In 1873 Congress made provision for beginning the work of restoration or reconstruction of this canal under a project which had

been prepared to cover this same section which the Board has now under consideration. A larger canal than the first was proposed. The locks were to be 300 feet long and 70 feet wide; the canal 100 feet wide on the bottom, and the navigable depth to be 6 feet. In 1877, however, with a view to reducing the cost, a modification of the plans was permitted which reduced the width of the locks to 60 feet and the navigable depth to 5 feet, and which left out the portion below Campbells Ferry and provided for improving that section of the river locally known as "Little Muscle shoals" by regulation work. A modification was also authorized of the plan for the upper portion of the canal above Lambs Ferry, whereby there was to be substituted for the continuous canal on the right bank a short section of canal, with two locks, on the left bank; the rest of the distance to be improved by regulation works.

8. The average slope of the river from the lower end of the present canal to Florence is about 3 feet to the mile; and it should be possible to secure by regulation a channel not less than 6 feet deep, in which the velocity of flow would not exceed 5 feet a second, and of a width which would be ample for navigation. With the help of the lift gained by the two locks in the short section on Elk River shoals, similar results could there be obtained. But they have not yet been obtained; and the difficulties which steamboats encounter now in passing between Florence and Decatur are not found within the limits of the completed canal, but are upon the length of the river before the canal is reached and after it is left. At low water in the river there are depths on these sections considerably less than 3 feet; while the canal itself, except at its entrance and exit, affords a depth of not less than 5 feet. There has been no case of a steamboat which succeeded in entering the canal being unable to pass through it because of the difficulties that it offered to navigation. So that in considering this canal as an improvement of the section of river which the Board was required to inspect, it must be regarded as an unfinished work, covering the worst part of the obstruction but hardly touching the rest.

9. A section of river like that in question can be improved for navigation in two ways: One is to pass it by a lateral canal, leaving the river undisturbed; the other is to divide the slope up into a series of ponds or pools by means of dams, and to afford a passage from one pool to another by locks. Each of these methods of improvement has advantages and disadvantages of its own. Perhaps the best thing that can be said of a lateral canal is that it is a safe method of improvement and one which is little likely to be injured by any natural causes. Presupposing that the embankments are high enough to keep the whole thing from being inundated in time of freshets, then the worst thing that can happen to it is that the embankment may be broken. If this happens, all of the water in one of the levels will escape into the river. The break will not be a very large one, because the volume in the level is not great enough to produce a very long or violent flow. When the water has all escaped, the break will be exposed and in a favorable condition for rapid repair, so that in a short time the canal can be put in service again; while in the case of a dam across the river itself, if a break occurs the whole discharge of the river is behind it, and the result is usually the almost total destruction of the dam. The cost of repair

would necessarily be very great, and the time required to make it would be long; and during the period of construction all navigation would be necessarily interrupted. But the lock and dam project presents the advantage that navigation between the locks is in large pools of ample depth, in which boats can move at full speed and with the maximum facility; while in the case of the lateral canal its narrowness, shallowness, and perhaps its crookedness, make navigation through it slow and tedious. Again, in the case of the lock dam, an increase in depth over the miter sill will result as the river rises; while the depth is necessarily the same for all stages of the river in all the locks of the canal, except at the upper gate of the upstream lock and at the lower gate of the downstream one. Again, a lateral canal does not lend itself to the development of water power, while an improvement by locks and dams may permit such development to the highest degree justified by the interests of navigation.

10. Now the query is submitted to the Board as to whether this stretch of river can be improved by not more than three locks and dams. In order to test this, the Board has caused its secretary to prepare a preliminary study of the improvement of this reach by three locks and three dams. The result of this investigation is submitted herewith. It is not designed as a working plan, but is simply a study which will develop the difficulties to be encountered and a possible means of solving them.

11. Owing to the comparatively low site of the city of Florence, which is at or near the lower end of the proposed improvement, it is impracticable to make use of a high dam here without inundating a valuable portion of the city. If the three dams could be of equal height, they would still have to be more than 40 feet high; but as the height of the lower one, for the reason just stated, must be much less, the height of the other two has to be greatly augmented. While it is undoubtedly possible to construct a lift lock with a lift of 40 feet, or even more, the Board is not prepared to give its unqualified indorsement of such a lock where it is to be used for the passage of the class of vessels used in the navigation of fresh-water rivers. In view of the height proposed for the dams and the lift of the locks, greater than that of any river lock known to the Board, and in view of the probable character of the rock in the bed of the river, which in places contains fissures, caves, and underground channels, the Board desires to emphasize the importance of a thorough investigation and exploration of the foundation at each site, in order to insure the stability of the structures before any dams of such height are approved.

12. Therefore the Board is of the opinion that it would not be to the advantage of navigation to attempt the improvement of the entire section described in the act of Congress first herein referred to by not to exceed three locks and three dams. A portion of it could undoubtedly be so improved, and the whole of it could be advantageously improved by a greater number of dams than that mentioned in the law.

13. These dams could be used for the development of water power, as well as for the improvement of navigation; but the regulation of the flow of the river must be absolutely under the control of the United States, in order that the river below may not at any time have the flow unduly restricted nor be subject to sudden rises owing to exceptional discharges at the dams.

14. Two plans have been submitted to the Board by private or corporate agencies for the development of water power at Muscle shoals. The first of these is submitted by the Muscle Shoals Power and Development Company. This plan provides for the construction of a single dam only, which starts from the right bank of the Tennessee River near Lock No. 6 of the present Muscle Shoals Canal and extends obliquely across the river, having a length of 8,800 feet. Beyond this it is continued almost as much farther by means of an earthen embankment built upon a series of islands. Below this the dam unites with the left bank of the river, and it is here that the installation is made for the development of power. This construction would be of no advantage whatever to navigation. It provides no lock, and furnishes no navigable pool. It is a plan for the development of water power, pure and simple. It might, and probably would be, detrimental to the existing navigation of the river, because when the water was low and a large amount was being drawn to the power house, the present navigable channel below Lock No. 9 and thence to Florence would be robbed of a portion of the flow that naturally comes to it, and its present bad condition would be made much worse. The Board is therefore of the opinion that this plan ought not to be favorably considered by the Government.

15. The other plan is submitted by what is known as the Muscle Shoals Hydro-Electric Power Company. This provides for the construction of three dams along the section of river under consideration. The first dam, however—that is to say, the one farthest downstream—is not at or near the Florence Railway bridge, but nearly 3 miles above it, at the head of Pattons Island, thus leaving entirely unchanged and unimproved a corresponding length of navigable channel, which is now in bad condition and which would be made much worse by the dam. The three dams cross the river practically at right angles, each about 40 feet in height, and divide the remaining portion of the section under consideration into three pools; but the plan will not afford 6-foot navigation throughout the lower pool without considerable rock excavation.

16. Each of these dams is to be passed by a lock having 6 feet on the miter sill at ordinary low water in the river (that is to say, when the pools are full), and having the same horizontal dimensions as the existing locks of the Muscle Shoals Canal. Such an arrangement, if made and properly maintained, would be of advantage to navigation. The lower dam would improve a portion of Little Muscle shoals for a length of about 4 miles, upon which the present navigation is very bad. The upper dam would completely improve the navigation between Lock No. 1 and Lock B, where the navigation is now bad in places; and it would extend the pool up to the head of Browns Island, completely doing away with the Elk River shoal. The plan reduces the number of locks from 11 in the now partially completed lateral canal to 3, or from 15, which would be necessary in a complete lateral canal, to 3, and correspondingly diminishes the cost of operation and care; but it would substitute locks of higher lift than have hitherto been tried in a river of this character for something that is tried and known to be safe. It would afford only a foot more ble depth at ordinary low stages of water than now exists in tially completed canal, and this additional foot could be easily

attained in the canal by raising the banks, lock walls, and lock gates at small cost.

17. The present canal is safe. No very serious accident could take place in it, and nothing could happen which could not be quickly repaired. In case of an accident to one of the proposed three dams, however, navigation would be completely interrupted and probably could not be restored within a year, or perhaps even for a greater period. A company may guarantee to maintain structures of this kind, but what redress would the Government have if the dam should break and the company fail?

18. The dams proposed by the Muscle Shoals Hydro-Electric Power Company seem to be very closely designed. In view of the magnitude of the disaster that would result from the failure of any of these structures, it would seem that they should be sufficiently strengthened to give absolute assurance of safety. A failure of one of these dams would not only mean a large expenditure by the United States in its rebuilding, but also the loss of the use of the river for purposes of navigation for from one to two years.

19. The Board is of the opinion that no portion of the expense of an improvement in strict accordance with the plans submitted by the Muscle Shoals Hydro-Electric Power Company should be borne by the United States. For reasons previously stated, their plans should be so modified as to strengthen the dams sufficiently to give an absolute assurance of safety from disastrous failure, and the depth and dimensions of the locks should conform to what Congress may decide to be sufficient for the Tennessee River for all future time. Were these plans so modified, then the Board is of opinion that the United States might properly bear such portion of the expense of the work as would be measured by the cost of completing the existing canal system between the head of Pattons Island and the head of Elk River shoals. This is practically equal to the amount that it would probably cost to construct the locks needed for the proposed three dams, and it would possibly be a more satisfactory division of work and jurisdiction for the United States to assume the cost of construction of the locks and permit every other part of the works to be constructed by such private or corporate agency as might desire to develop the water power.

To recapitulate:

20. The Board has examined the present condition of the United States Canal and the Tennessee River as required by law, and finds that the stretch of river therein referred to can not advisably be improved by means of not more than three locks and dams, and that at least four locks and dams would be necessary.

21. By omitting the section of river from the Florence Railway bridge up to the head of Pattons Island, the Board finds that the remaining portion can be improved by private or corporate agency, in conjunction with the development of water power, by means of not more than three locks and dams.

22. The Board has examined all plans submitted, and disapproves the plan of the Muscle Shoals Power and Development Company. The plans of the Muscle Shoals Hydro-Electric Power Company are not without merit; but, in view of the magnitude of the disaster that would result from the failure of any of these works, the Board is of

opinion that the structures shown in these plans should be sufficiently strengthened to give absolute assurance of safety.

23. Any authorization of plans of this character should be subject to their approval by the Secretary of War, in order that the above feature of the case may be properly safeguarded.

24. The Board is further of opinion that works of this character, if made sufficiently strong, will be advantageous to navigation and can be used to develop water power.

25. The Board is of opinion that the United States might properly bear such portion of the expense of such works as would be measured by the cost of completing the existing canal system between the head of Pattons Island and the head of Elk River shoals; and that this is practically equal to the amount that it would probably cost to construct the locks needed for the proposed three dams. The cost of every other part of the works should be borne by such private or corporate agency as might desire to develop the water power.

26. Should such arrangement be made, it is further believed that the Government would do well to impose similar conditions to those found acceptable at Hales bar. These conditions should include the control of the flow by the United States, the furnishing of free light and power for operating the locks, and the reversion of properties to the United States at the end of ninety-nine years.

27. The horizontal dimensions of the locks and the low-water depth on their sills should be what Congress may wish to adopt for the ultimate improvement of the Tennessee River. It will be very difficult and expensive, if not impossible, to change these dimensions later.

Very respectfully,

WM. T. ROSSELL,
Lieut. Col., Corps of Engineers.
DAN C. KINGMAN,
Lieut. Col., Corps of Engineers.
C. S. RICHÉ,
Major, Corps of Engineers.
HENRY JERVEY,
Major, Corps of Engineers.
J. R. CAVANAUGH,
Captain, Corps of Engineers.
W. G. CAPLES,
First Lieut., Corps of Engineers.

Brig. Gen. A. MACKENZIE,
Chief of Engineers, U. S. A.

APPENDIXES.

1. Report of Lieutenant Caples, 5 blueprints accompanying.
2. Participation by the United States Government in the cost of Muscle Shoals improvement not an instance of Government aid.
3. Map showing general plan of Muscle Shoals Hydro-Electric Power Company.
4. Stream flow diagram, Chattanooga, mean and minimum. By Muscle Shoals Hydro-Electric Power Company.
5. Stream flow diagrams. (Muscle Shoals Hydro-Electric Power Company.)

6. Location of Muscle Shoals Hydro-Electric Power Company's proposed Lock No. 1.
7. Pattons Island boat channel. Map. (Muscle Shoals Hydro-Electric Power Company.)
8. Site of proposed Dam No. 1. (Muscle Shoals Hydro-Electric Power Company.)
9. Proposed lock plan and sections. (Muscle Shoals Hydro-Electric Company.)
10. Proposed power-house plan, section, etc. (Muscle Shoals Hydro-Electric Power Company.)
11. General plans. (Muscle Shoals Hydro-Electric Power Company.)
12. Lock and Dam No. 2; map. (Muscle Shoals Hydro-Electric Power Company.)
13. Site of Lock and Dam No. 2. (Muscle Shoals Hydro-Electric Power Company.)
14. Site of Lock and Dam No. 3. (Muscle Shoals Hydro-Electric Power Company.)
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16. Plans of Muscle Shoals Power and Development Company.
17. Description of the engineering plans of the Muscle Shoals Hydro-Electric Power Company.
18. Reciprocal relations of the Government and the Muscle Shoals Hydro-Electric Power Company in connection with the proposed improvements at Muscle Shoals.
19. History of Muscle Shoals Hydro-Electric Power Company and what it claims.
20. Legal foundation upon which rests the water-power projects of the Muscle Shoals Hydro-Electric Power Company at Elk River Shoals and Muscle Shoals, Tennessee River, State of Alabama.
21. Federal participation in corporate and private projects which are calculated to establish commerce among the States or in furtherance of other projects for the public welfare, etc.
22. Commercial aspect of the Elk River and Muscle Shoals situation.
23. Development of power at Muscle Shoals by a single corporation preferable in the public interest to the extension of a number of companies.
24. Abandonment of Muscle Shoals Canal and adoption of slack-water navigation the only practicable plan, etc.

APPENDIX No. 1.

PROJECT FOR THE IMPROVEMENT OF THE TENNESSEE RIVER FROM THE HEAD OF ELK RIVER SHOALS TO THE FLORENCE RAILWAY BRIDGE.

By W. G. CAPLES,
First Lieutenant, Corps of Engineers, U. S. Army.

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PROJECT OF LIEUTENANT CAPLES.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., September 1, 1907.

COLONEL: 1. In compliance with your orders, I have the honor to submit the following project for the improvement of the Tennessee River between the head of Elk River shoals and the Florence Railway bridge.

2. The problem presented by Congress is to improve this section by not to exceed three locks and dams. As this seems hardly a desirable mode of improvement, two alternative projects are submitted; one for the improvement by three locks and dams, two of which will be available for power development, and the other for the improvement by four or possibly five locks and four dams, three of which will be available for purposes of power development. As no mention is made of navigable depth, each project is figured both for 6 and for 9 feet navigable depth. For the reason that these works, if installed, will determine for a great period of time—practically for all time—the greatest navigable depth for which improvements will be made above these works, the improvements by four or five locks and four dams to provide a navigable depth of 9 feet is favored.

3. The extent of this section requires determination on account of its upper limit. The lower limit is definitely fixed by the Florence Railway bridge. There is, however, some difference of opinion as to what is the head of Elk River shoals. For purposes of division of appropriations this has been arbitrarily considered as the gauge pier above Lock A. The maps and a personal examination show that this division is purely one of convenience, as the Elk River shoals actually extend uninterrupted to the head of Browns Island. The head of Browns Island being the actual head of the shoals, this point, rather than an arbitrary point in the shoals, is taken as the head of Elk River shoals. Practically the same point was taken by Capt. William R. King in his project of 1877, and by Maj. Walter McFarland and Col. J. W. Barlow in the extent covered by their maps, which were to cover this section.

4. This section of the river has a total length of about 38 miles and a total fall of 131.2 feet. Except for the section between Nances reef and Lock 1, and for the Bainbridge eddy, the river is very wide and shallow, full of islands, and quite swift. No gaugings have been taken of the flow over these shoals, but it is practically the same as at Riverton, Ala., where extensive gaugings have been made. The lowest gauged flow at Riverton is 10,250 cubic feet per second. This gauging was made by Asst. Engineer G. W. Brown on October 8, 1894 (a period of very low water), when the river was stationary and 1.0 foot below the zero of the gauge then in use. The highest flow gauged at Riverton was 372.120 cubic feet per second. This was the crest of a rise reading 40.0 feet on the Riverton gauge, and was measured by Asst. Engineers G. T. Nelles and W. S. Winn on March 21, 1899. Extreme high water has been computed at 508,000 cubic feet per second. High banks are comparatively close, except at the head and the foot of the improvement, and at the mouths of some creeks. The location and dimensions of works of improvement are limited by the necessity of preserving the city of Florence, Ala., from flood, and by the desirable preservation of the engineer shops at Lock 6, Muscle Shoals Canal.

5. The requirement that the city of Florence shall not be inundated limits the lift of the first lock, which for both projects is set about 1,000 feet upstream of the Florence Railway bridge. The desideratum of preserving the Government shops at Lock 6 and the practicable height of lift limit the location of the second lock to the head of Patton Island, and its lift to about 40 feet, for both projects. The third dam is limited in location by the lift of the second.

In the case of the project for improvement by three locks and dams the lift of this lock is forced to be 83½ feet. While this lift is possible by means of hydraulic lift locks, it can scarcely be said to be desirable. It is an open question if the protection of the foundations of the dam could be accomplished. The guard walls would have to be greatly extended, and a number of other items would be unreasonably increased. In the case of the project for improvement by four locks and dams, the lift of this lock would be limited to about 40 feet, to provide a suitable location for the fourth lock. The fourth lock, in turn, would have its lift determined by the extent of the improvement.

6. The determination of the dimensions of the locks and of the navigable depth depends upon the class of prospective commerce. It is safe to say that the local commerce of the Tennessee River probably would never warrant an improvement of the magnitude projected. We must then turn to its resources of prospective through commerce. These are as follows:

(*a*) From the Elk River: Phosphate rock.

(*b*) From the Clinch River: Coal, marble, iron, and zinc. The Clinch River coal field is one of the great deposits of high-grade bituminous coal.

(*c*) From the Holston River: Marble.

(*d*) From the French Broad River: Marble.

(*e*) From the Little Tennessee River: Slate. (However, this is of doubtful value.)

(*f*) From the upper Tennessee River: Coal, iron, and marble.

That these are not now shipped is due to the lack of improvement of the river, except in the case of the slate from the Little Tennessee, which appears to be of poor quality.

An examination of the above shows that a large commerce in bulky products may be expected when the navigation of the river is made profitable by improvements. The economical handling of these products requires large tows. From Hales bar up the navigable depth for which improvements will be made is being fixed, by that work, at 6 feet. Leaving out Muscle Shoals Canal, which will be eliminated by this improvement, there is nothing to set a depth below Hales bar. Colbert Shoals Canal provides for boats drawing 6 feet at extreme low water. At ordinary stages the depth available will be greater, and at the stages at which great fleets are shipped the boats will run in the open river and can draw 9 feet. The improvements now undertaken on the Ohio River indicate that in all probability 9 feet will eventually be the depth for which improvement is made, unless some great works limit the depth to less. There is no reason why 9 feet depth can not be obtained from Hales bar to the mouth of the Tennessee River. To encourage navigation it must be made profitable. The greater the tows that can be handled the more profitable will be the handling. If these works are installed on too small a scale, either they will have to be changed at very great expense or the commerce of the valley of the Tennessee will be unduly restricted.

7. The above considerations have governed in the design of locks and in navigable depth. Six feet appears to be the least depth on which mineral products can be profitably handled, and 9 feet would be much more desirable. Passage over the dams will never be possible. The works proposed will absolutely limit the navigability of the river. Therefore 9 feet navigable depth and large locks are favored.

8. It would be impracticable to build locks large enough to pass an unbroken large tow. We have, then, to seek a mean between profitable lockage and practicable size of locks. The ordinary Ohio River coal barge is 135 feet by 25 feet. The length of towboat to handle large tows of these barges may be taken at 300 feet. As the maximum tow, 63 barges are assumed. Three barges side by side have a width of 75 feet. Allowing 15 feet play, we have 90 feet for the width of the lock chamber. Assuming that 9 barges are taken through with the towboat at one lockage, the length of tow locked will be 705 feet. With the upper miter sill 10 feet wide below the gate and the chamber 90 feet wide, the required distance between hollow quoins will be 765 feet. To this add 35 feet for safety in maneuvering the tow, and we have 800 feet for the length of the lock between hollow quoins. If we assume that the towboat handles the tow unaided, 7 lockages up and down at each lock must be made. The filling and emptying of the lock will require about forty minutes, opening and closing the gates ten minutes, moving into and out of the lock ten minutes, and making and breaking the tow at least fifteen minutes for each double lockage, or eight and three-fourths hours for seven. This will require thirty-five hours plus the time of travel to pass through the four locks, or about thirty-nine hours. This is really a minimum. Forty-eight hours would be a safer esti-

mate to put on the time. By making only one lockage of the main towboat and using two tenders the passage could be accomplished in thirty to thirty-six hours.

The Tennessee coal field has an advantage of from 0 to 300 miles over the Ohio coal field in distance to tidewater. Each hour required for lockage takes off about 6 to 8 miles of this advantage. These works, even at the best, would put the Tennessee coal field on about the same basis of distance from tide water in point of time. The locks could not very well be made larger on account of the great size of the gates and the difficulties of filling. Nor should they be made smaller, if it is desired to develop a mineral commerce in competition with that on the Ohio.

9. The general design of the locks will be the same as used at Hales bar, Tennessee River, with some few modifications. The filling and emptying will be by culverts extending the length of the lock, having openings into the lock and closed at each end by valves. There will be one culvert in the land wall and one culvert in the river wall. The gates will be of the type recommended by the Board on Deep Waterways. The upper guard wall will be solid to 10 feet below low-water surface, except for a drift sluice at the lock. Below 10 feet below the low-water surface arched openings will be placed to maintain the level on both sides, and thus prevent excessive draw through the drift sluice. The lower guard wall will extend well below the toe of the dam. Guide walls will be built on each end of the lock equal in length to the guard walls. The gates will be operated electrically. The guard of the lock will be such as to prevent the lock from ever being drowned out.

10. The dams will be of the same type as used at Hales bar. The top width will be 5 feet for the Florence dam and 8 feet for the others. The back will be vertical. The front slope will be 7½ horizontal to 10 feet vertical for the Florence dam, and 8½ to 10 for the others, joining the base with an arc of a circle whose radius is 40 feet. The dams will be set 4 to 5 feet into solid rock, and, in the case of all lifts of 40 feet or over, will have an apron 300 feet wide by 6 feet thick, composed of derrick stone not less than 2 tons in weight closely bedded in concrete. A tunnel will extend through the dam, and pipes will extend from the tunnel to the face of the dam to prevent the formation of a vacuum on the face.

11. The abutments will be of the same elevation as the lock walls and will extend 200 feet upstream and 1,000 feet downstream of the toe of the dam, where the natural rock does not form a sufficient abutment.

12. Cyclopean concrete will be used throughout, except that the culverts and floor will be lined with vitrified brick.

THE FLORENCE DAM.

13. *Location.*—To provide for the safe passage of the drawbridge, the dam will have to be situated about 1,000 feet upstream of the Florence bridge. This bridge crosses the river approximately normal to the left chute and at approximately 45° to the right chute. The lock should have its center line approximately normal to the center line of the bridge. For reasons given later, this lock is located on the left bank. If, now, the whole dam be normal to the lock, it will cause excessive scour to the right bank. If, on the other hand, it be normal to the right bank it will throw the overfall into the lower entrance of the lock. Either is objectionable. An arched dam would put excessive strain on the river wall of the lock—if, indeed, it would not cause its failure. The solution offered is a broken back dam running from the left bank of Pattons Island normal to the left chute, thence to the right bank normal to the right chute.

14. *Height of crest.*—Opposite the head of Pattons Island, the location of the second lock and dam of this series, rock occurs at elevation 403. To give 6 feet at low water at this point will require the crest of the Florence dam to be at elevation 409. For safety it is taken at 409.7, or 13 feet above low water. For 9-foot navigation the crest is placed 3 feet higher. This is the preferable method, since the increase in height involves only the additional quantity of 7,000 cubic yards of concrete; while the retention of the crest at elevation 409.7, —th rock excavation at the head to obtain a 9-foot channel, would involve 00 cubic yards of rock excavation. At the prices taken for estimating, ring 20 per cent for contingencies, the advantages of the high dam are a st of $1,017,000, and safer, freer navigation.

Fixed or movable dam.—The width of the river at this point is nearly eet, following the line of the dam, or about 2,700 feet, following the

shortest line. Rock occurs at elevations from 390 to 394. If a movable dam is used the sill of the navigation pass will be at elevation 392, and that of the weir at elevation 398. Assuming that a swell head of not over 0.5 foot be desired (report of Major Lockwood, Ann. Rep., 1897, p. 2538 et seq.), to pass 70,000 cubic feet per second (equivalent of a 10-foot stage on the Chattanooga gauge) will require a weir 1,600 feet long and a navigation pass 1,000 feet long. On account of the difficulty of maneuvering such great lengths of pass and weir, and on account of the great length of structure left exposed to the action of the heavy drift carried by this river, a movable dam scarcely appears suitable. The chief land damage will be for the destruction of Pattons Island. This island will probably be so badly injured by the second dam of the series that it will have to be purchased in any case. This removes the chief objection to the fixed dam, which is therefore adopted.

16. *Depth on crest.*—For this determination we use the formula for weir discharge:

$$H=3\sqrt{\frac{(Q)^2}{M\,L\,8.03}}$$

in which H=depth on crest;
Q=discharge in cubic feet per second;
M=a coefficient, taken here as 0.38;
L=length of crest, taken here at 2,000 feet.

The length of crest is assumed at 2,000 feet, allowing 200 feet for the projection of the lock into the river and assuming that the poor approach to the dam through Pattons Island will be equivalent to a reduction in crest length of 500 feet. This is not strictly accurate, but the error is on the side of safety. We assume the discharge to be the same as at Riverton, which is practically true. The extreme range at Riverton is 52.5 feet. The highest gauging is at 40 feet. Values above 40 feet are interpolated.

The following values of Q are taken in thousands of cubic feet per second for the various stages on the Riverton gauge:

Stage	0	5	10	15	20	25	30	35	40	45	50	52½
Discharge in thousands of cubic feet per second	10	37	69	103	150	200	250	305	360	418	478	508

The extreme high-water discharge is that used by the Muscle Shoals Hydro-Electric Power Company in their computations, and is approximately correct.

The extreme fluctuation at Riverton (52.5 feet) corresponds to 32.6 feet at Florence, from which we have that 3.1 feet on the Florence gauge probably equal 5.0 feet on the Riverton gauge. The elevation of low water at Florence is 396.7, and of high water 429.3.

Applying the formula, we have:

Stage.		Discharge.[a]	Depth on crest.	Elevation.	
Riverton.	Florence.			Upper pool (crest of dam, 412.7).	Lower pool.
			Feet.		
0	0	7	1.10	413.80	396.7
5	3.1	37	3.32	416.02	399.8
10	6.2	69	5.04	417.74	402.9
15	9.3	103	6.58	419.28	403.0
20	12.4	150	8.46	421.16	409.1
25	15.5	200	10.24	422.94	412.2
30	18.6	250	11.88	424.58	415.3
35	21.7	305	13.57	426.27	418.4
40	24.8	360	15.15	427.85	421.5
45	27.9	418	16.74	429.44	424.6
50	31.0	478	18.31	431.01	427.7
52½	32.6	508	19.06	431.76	429.3

[a] In thousands of cubic feet per second.

NOTE.—With the crest at elevation 409.7 the elevation of the upper pool will of course be 3.0 feet lower, and the dam will drown out at about the 31-foot stage on the Florence gauge.

From which we see that at extreme high water there will still be 2.46 feet fall over the dam. The remaining fall, however, will probably be less, as at high stages the bad approach over Pattons Island will have less effect.

If the crest of the dam is placed at 409.7, to provide for 6-foot navigation only, the dam will be drowned out at about the 31-foot stage on the Florence gauge. This is probably accounted for by the contracted cross section of the river below Florence. At high water there is a depth in the two chutes naturally of about 39 feet, with 12 feet over Pattons Island. Below the Florence bridge the river narrows to 1,500 feet between banks, with a bluff on one side and bottoms on the other. These bottoms are submerged 10 to 12 feet at high water. This gives roughly the same cross section for discharge as at the Florence dam.

17. *Guard of locks.*—The banks on the right chute are at about elevation 420, which will place them just awash at a stage of about 10 feet at Florence. During the past eleven years this stage has been exceeded, on an average, forty-five days each year, the average number of times being 5. Data for the 10, 18.6, 21.7, 24.8, and 27.9 foot stages are given in the following table:

Number and duration of given stages, 1896–1906.

Year.	Stage exceeded (Florence gauge).									
	10.		18.6.		21.7.		24.8.		27.9.	
	Times.	Days.	Times.	Days.	Times.	Days.	Times.	Days.	Times.	Days.
1896	4	37	1	4						
1897	5	55	2	18	1	13	1	8	1	3
1898	4	28								
1899	3	67	2	22	1	12	1	4		
1900	7	44	1	3						
1901	9	72	1	3						
1902	5	48	2	9	1	1				
1903	5	70	2	3						
1904	1	10								
1905	5	29								
1906	8	36								

A 31.9-foot stage has been reached but once in eleven years, and then for only part of a day.

Allowing that the lock must be always available for use, since the higher stages are the ones on which large tows run, the elevation of the lock walls would have to be 430 for continuous navigation. This might be very rarely drowned out for a few hours, but for all practical purposes the lock can be considered as always open to navigation. If there is no objection to the locks being occasionally out of use, it is evident from the above that this elevation may be reduced 4 feet.

18. *Choice of bank.*—The right chute is used at present, and the town of Florence has access to this channel. The channel curves in such a manner that it is crossed by the Florence bridge at an angle of about 45°, thus materially reducing the effective clearance in the draw span of the bridge. The total clearance is 184 feet, while the effective clearance is only 130 feet. Handling a boat through this span requires no little skill, and is somewhat dangerous. At low stages the clearance is still further reduced, until probably not over 80 feet are available for boats. The handling of boats and large tows through this draw would be a matter of excessive danger.

On the left bank the direction of banks and flow are about at right angles to the bridge. The left bank has much better approaches for a lock, and is the one preferable for use. The objection to locating the lock on this bank is that there would remain no natural channel from the upper pool to the right bank. The second dam of the series crosses the head of Pattons Island, and the Florence dam crosses the lower end of the same island. At the lower end the island will have to be cut away to bed rock to allow the water to get to the dam, and at the upper end the island will be entirely eroded by the wash from the second dam of the series. Neither of these chutes could be used as a boat channel, for obvious reasons. Between them the island forms a com-
a bar to crossing.
ow the Florence bridge is the town wharf, and this would be available
night if the right chute were closed. Of course it would necessitate

teaming all freight carried by water, but this is purely a local disadvantage, and not comparable with the greater disadvantage of having to take large tows through the draw span.

It appears better to place the lock on the left bank and to require new draws to be placed in the bridge next to that bank.

19. *Access to city of Florence.*—As stated in the preceding paragraph, this can be had by teaming to the wharf below the Florence bridge. This, however, will not permit of the reduction in freight rates which would ensue from direct water transportation. Below the Florence bridge the bottoms are too low to permit of manufacturing sites, while above the bridge there are some high banks which would form excellent locations for new industries which will undoubtedly follow the development of cheap power. Access to these may be a matter of sufficient importance to merit the consideration of the Board.

It can be had by either of two methods; first, by dredging a channel across Pattons' Island about 7,000 feet below the second dam of the series; second, by placing a small lock, about 300 by 60 feet, in the right chute. The first method is open to the objection that it involves a channel crossing the direction of flow, and consequently expensive to maintain and difficult to navigate. The second method is open to the objection of great first cost and probable considerable cost of maintenance. From the standpoint of navigability the second method is favored. Both plans are, however, presented for the consideration of the Board.

22. *Conclusion of premises.*—

(*a*) Lock located on left bank.

(*b*) Top of lock walls at elevation 430.

(*c*) Fixed dam; crest at 409.7 for 6-foot navigation or at 412.7 for 9-foot navigation.

(*d*) Access to city of Florence by lock in right chute, in case the Board considers this necessary.

23. *Cross sections of main lock walls.*—The base of the wall is assumed in all cases to be at elevation 390, top at 430; height 40 feet. The worst case for the river curtain wall is with water inside at elevation 427 and the water outside at elevation 418, say 416 for safety. The overturning moment of this pressure is 345,000 foot-pounds. The cross section of a wall 24 feet on the base, 6 feet on top, and 40 feet high is 600 square feet. Its weight at 140 pounds per cubic foot is 84,000 pounds. Its lever arm about the outer toe is 15.6 feet, giving a resisting moment of 1,310,000 foot-pounds and a factor of safety of 3.8.

The worst case of the land curtain wall is with the earth behind it level with the top and the water in the lock chamber drawn off. Assuming the weight of 1 cubic foot of earth as 100 pounds, the moment from the horizontal pressure is 305,000 foot-pounds. The lever arm of a wall of cross section similar to the river curtain wall is 8.4 feet, and its resisting moment is 705,000 foot-pounds, giving a factor of safety of 2.3, neglecting the vertical pressure of the earth. If this be considered, the factor of safety increases to 3.7.

For the buttresses the lower river buttress will be taken, as it is the critical one, and the others will be assumed to be of the same cross section. The worst case is with the water inside at elevation 427 and the water outside at elevation 416 (as found for land curtain wall). It will be assumed that 25 feet of wall takes all the gate thrust, half upstream and half downstream of the sill. The 12½ feet upstream supports also the net water pressure. The moment of the transverse component of the gate thrust on a gate 48 feet in length is 24,709,000 foot-pounds. The 12½ feet upstream each take 988,360 foot-pounds; to which must be added the net overturning moment of the water, 345,000 foot-pounds, making a total of 1,333,360 foot-pounds. We assume a wall 24 feet wide on top and 36 feet wide on the base. The cross section of this wall is 1,200 square feet, and the weight per running foot is 168,000 pounds. Its moment against overturning is 3,578,400 foot-pounds, giving a factor of safety of 2.7 for the most unfavorable case and 3.0 for the average case. It will be observed that in figuring the thrust of the gates an error on the side of safety was made in not taking into account the back pressure on the gates of the water in the lower pool. The actual factor of safety will considerably exceed that given (4.43 for the average case). The quantities of concrete omitted in the culverts are considered to be counter balanced by the quantities in the lift and coffer walls, for purposes of computation. No estimate is made, therefore, for the lift and coffer walls.

21. *Cross section of dam.*—The dimensions taken are as follows: For 6-foot navigation (crest at elevation 409.7), the top width will be 5 feet, slope of front 7½ horizontal to 10 vertical, joining the base by an arc, the radius of which is 20 feet. The maximum net overturning moment will be 126,000 foot-pounds. The resisting moment, neglecting the water pressure on the surface, will be 393,000 foot-pounds per running foot of dam, giving a factor of safety of 3.12. For 9-foot navigation the crest will be at elevation 412.7, and the top width, front slope, and connecting arc will be the same as above. The maximum net overturning moment of the water will be 200,250 foot-pounds, and the net resisting moment of the dam will be 573,340 foot-pounds per running foot of dam, giving a factor of safety of 2.86. If we consider the pressure of the water on the crest and face of the dam the factor of safety will exceed 3.

25. *Concrete in lock and dam.*—The concrete involved in this construction is as follows:

	Cubic yards.
4 buttresses	16,700
2 curtain walls	31,600
Guide and guard walls	40,900
Wing walls	13,500
Dam	29,200
Total	131,900

This is based on the following dimensions:

Buttresses 90 by 29 feet on top, 114 by 41 feet on bottom, and having gate recesses 50 by 5 feet; all by 40 feet vertical.

Curtain walls, 710 feet long between buttresses, 6 feet on top, 24 feet on bottom, 40 feet high.

Guide and guard walls of the same section as curtain walls. Lower guide and guard walls 200 feet long; upper guide and guard walls 800 feet long. An allowance of 20 per cent reduction in section of the upper guard wall is made to compensate for the arched openings.

Wing walls of the same section as curtain walls. Each return 300 feet long to back of fill.

Dam of the section given for 9-foot navigation. For 6-foot navigation this requires 7,000 cubic yards.

These quantities in the lock may be reduced by allowing the lock to flood out at the higher stages and by reducing the factors of safety. The head bay has been made of practically the same dimensions as the chamber, and the tail bay of such dimensions as will protect the boats for a space of 1,000 feet below the dam. It may be possible to reduce these by giving less ease and safety to navigation. Guard piers may be used above the lock, but they are not so good as the solid wall above the level of the keels of boats, on account of the draw through them. (It is admitted that there are some prominent advocates of guard piers, but preference is given to the other side of the argument.)

The main object entertained in the whole design has been rather to give the very best construction than to try to economize on certain details, which supposed saving might later be found to be false economy.

26. *Abutment and earth dam.*—The banks on the Florence side are below the elevation of high water, which requires an earth dam beyond the abutment. This earth dam must be above any possible high water, and its river end must be protected against any possible erosion. Provision must be made against any possible leaks or seepage through the earth dam, and its slopes must be safe against slipping even when saturated. This is best attained by an earth dam with its crest at elevation 440 (7.5 feet above the highest recorded water), with a top width of 24 feet and side slopes of 1 vertical to 4 horizontal; protected in the center with a core wall to bed rock and at the river end by the abutment. The side slopes may appear unnecessarily flat. In support of the flat slopes may be offered the fact that the original plans [illegible] bar called for slopes of 1 on 2 and were later changed to 1 on 4. [illegible]ter slope offers a greater security against sliding, against seepage, and [illegible]sible erosion. With this slope, except at the river end, no pro-[illegible]er than Bermuda grass will be required, while the steeper slope [illegible]prapped for safety. The first block of the core wall next the [illegible]uld be made monolithic with the abutment to prevent any seepage [illegible]ck face of the abutment. At the higher stages the water above

the dam will flow along its face and have a tendency to scour out just behind the abutment. On the lower face the water will, by spreading out, tend to have the same effect. This is guarded against by paving the slopes for 300 feet back of the abutment. The whole earth dam will be planted in Bermuda grass.

The abutment will commence at the upper end of the earth slope, and will conform in elevation to the cross section of the earth dam and act both as a protection and as a retaining wall. Below the earth dam the abutment will extend for 300 feet at the elevation of the top of the natural bank. In the event that a lock is placed on the Florence bank, this abutment and core wall, with an increase in thickness at the buttress, will serve for the upper guide wall, buttress, and part of the land curtain wall. The abutment will be 6 feet on top, with base six-tenths of its height, and will involve about 10,000 cubic yards of concrete, while the core wall will require about 12,000 cubic yards.

27. *Cofferdams.*—For the lock and upper guard and guide walls a longitudinal coffer 2,000 feet long and three cross coffers, each 200 feet long, will be required. It is assumed that the land will act as one side of the coffer. For the dam, two cofferdams each 2,500 feet long will be required. For the abutment a longitudinal coffer 600 feet long and two cross coffers 50 feet long each will be necessary. In all, 8,300 linear feet of cofferdam will be necessary. The most suitable cofferdam, from experience on this river and on the Cumberland, has been found to be the crib type. Each cofferdam would consist of triple cribs of 8 by 8 inch timbers, or suitable round timber, spaced 10 feet centers. The inner and outer cribs would be filled with stone, and the center crib with clay or gravel covered with stone. A common mistake among contractors has been the building of cofferdams too low. For safety these should be made about 20 feet high—that is, to elevation 410, or enough to keep out a rise of 13 feet on the Florence gauge.

28. *Earth and gravel excavation.*—These quantities are very roughly estimated, as there is no detailed survey to serve as a guide. From the best available data they are estimated as follows:

	Cubic yards.
Lock	14,000
Lower approach	25,000
Abutment	6,000
Core wall	30,000
Dam	112,000
Total	187,000

29. *Rock excavation.*—As in the preceding paragraph, the quantities are necessarily very roughly estimated:

	Cubic yards.
Lock	14,000
Lower approach	3,000
Abutment	3,000
Core wall	6,000
Dam	3,000
Total	29,000

30. *Backfill and earth dam.*—Again the lack of a detailed survey causes the estimate to be approximate only:

	Cubic yards.
Earth dam	248,000

From this should be deducted 36,000 cubic yards from the core wall and abutment excavation, leaving 212,000 cubic yards to be paid for.

31. *Paving.*—The terreplein of the lock, the bank below the lock to elevation 435 for a distance of 500 feet, both slopes of the earth dam for a distance of 300 feet along the core wall from the abutment, and the banks on the abutment side to the top of the natural bank for a distance of 1,100 feet should be paved with a hand-laid paving. When first laid the joints should be chinked with small stones. Several years later, when settlement is complete, the joints should be grouted. As this grouting will come under "operation and care" rather than under construction, no estimate is made for it. The amount of paving is estimated at 84,000 square yards.

32. *Land.*—The following land (scaled from the map and taken from reports of surveys) will be overflowed:

	6-foot navigation.	9-foot navigation.
	Acres.	*Acres.*
Islands	461	461
Right bank	90	99
Left bank	35	38
Total	586	598

As the United States will no doubt have to settle some damages for lands made more often subject to overflow, and possibly others, it is considered advisable in estimating to flatly increase the amounts in each case to 800 acres.

33. *Lock houses.*—No plans have been drawn for these, and a flat estimate of $10,000 is made to cover this item.

34. *Operating machinery.*—No plans have been drawn for this, as the time at hand would not permit. The machinery at Hales bar will serve as a good guide. This will cost complete $15,000. Allowing 33⅓ per cent for probable increase in the cost of steel and machinery, $20,000 is estimated for the machinery of the Florence lock.

35. *Lock gates.*—The time at hand would not permit the preparation of detailed plans. Recourse is had, for purposes of estimation, to the cost of other large gates recently installed. The upper gates at Hales bar are 25 feet high and each leaf is 36 feet wide. The cost was about $14,000. The upper gates at the Florence lock will be 27 feet high and each leaf will be 48 feet wide. On the same basis the upper gates at the Florence lock would cost $31,500 and the lower gates, which are 40 feet high, would cost $78,500; a total for both sets of gates of $110,000. If we allow one-third increase in the price of steel, this amount becomes $147,000.

36. *Cost complete, without access to city of Florence—*

Concrete, 155,000 cubic yards, at $7	$1,085,000
Cofferdam, 8,300 linear feet, at $22	182,600
Earth excavation, 187,000 cubic yards, at $0.75	147,750
Rock excavation, 29,000 cubic yards, at $3	87,000
Earth fill, 212,000 cubic yards, at $0.75	159,000
Paving, 84,000 square yards, at $2	168,000
Land, 800 acres, at $100	80,000
Lock houses	10,000
Machinery	20,000
Gates	147,000
	2,086,350
Contingencies, etc., 20 per cent	417,270
Estimated total cost 9-foot navigation	2,503,620

If 6-foot navigation is adopted, this may be reduced by $150,000 saving on land, gates, and dam, making for 6-foot navigation a cost of about $2,353,620.

38. *Access to city of Florence, first method.*—This plan involves the cutting of a channel through Pattons Island near the mouth of Sweetwater Creek, about 7,000 feet below the second dam of the series. The general elevation of Pattons Island at this point is about reference 419. The elevation of low water for 9-foot navigation is 413.8. A 6-foot channel would then require excavation to reference 407. Assuming a channel 200 feet wide on the bottom (to allow for disadvantage of crossing direction of flow), with side slopes of 1 on 2 and a length of 4,000 feet, we find that it will involve about 400,000 cubic yards of dredging. This channel is directly across the current, and it is believed that it will continue to fill up and require redredging until the entire head of Pattons Island has been washed away by the second dam of the series. A channel of this length cut obliquely, as shown, would probably save its cost in maintenance. This work is straight dredging and could be done best by hired labor, at a cost of about 15 cents per cubic yard. The short channel would cost $60,000 and the long channel $120,000 for first installation.

38. *Access to city of Florence, second method.*—This would be by using the abutment in the project for the upper guard wall, the upper land buttress, and a portion of the land curtain wall (of course strengthening the wall at the buttress), and constructing a smaller lock to pass vessels into the right chute. Clear passage over Pattons Island for boats drawing 6 feet or less can be had at the 19.0-foot stage on the Florence gauge. For safety the lock walls should just permit of passage at the 21.7-foot stage. Since no large tows will pass through the lock, its chamber need not be any greater than those now in use at Muscle Shoals Canal (300 feet by 60 feet). The construction of such a lock will involve the following additional expense:

Paving, 7,000 square yards, at $2	$14,000
Concrete, 30,000 cubic yards, at $7	210,000
Rock excavation, 3,500 cubic yards, at $3	10,500
Cofferdam, 800 running feet, at $22	17,600
Back fill, 40,000 cubic yards, at $0.75	30,000
Lock houses	10,000
Lower gates	20,000
Machinery	1,900
	314,000
Contingencies, etc., 20 per cent	62,800
Total estimated cost	376,800

No allowance is made for upper gates and a very small allowance is made for machinery, as they can be brought from the locks at Muscle Shoals Canal, which will be drowned out.

39. *Summary.*—Of the two methods of access to the city of Florence the lock method is favored for the reason that it is better and that the cost of the dredged channel will probably be as great in the long run, on account of the great cost of maintenance. The total project for 9-foot navigation is, then, estimated at $2,880,420. The saving for reduction of navigable depth to 6 feet is so slight in comparison with the whole that it scarcely seems worth the making, when we consider that these works are to limit the navigability of one of our great rivers for practically all future time.

The charge of extravagance may be brought against this design, but when we consider that these works will provide amply for all navigation that can be foreseen, and will probably relieve the United States of ever having to tear them out and build larger, the cost is not excessive for the results desired and will more than likely prove true economy in the end. This is borne out by the fact that the increase in size of works of navigation on this river has not been able to keep pace with the increased demands of navigation.

LOCK AND DAM AT HEAD OF PATTONS ISLAND.

40. *Location.*—It is assumed that the location will be that proposed by the Muscle Shoals Hydro-Electric Company. This company has made investigations as to foundations which we have not. Their location is probably better than we could obtain without a special survey. The lock is located on the left bank. This location is forced by the location of the main lock at the Florence dam, and by the fact that Pattons Island will divide the upper pool of this dam into two pools.

41. *Height of crest of dam.*—This, for 6-foot navigation, is taken at elevation 452.5, as in the plans of the Muscle Shoals Hydro-Electric Power Company. For 9-foot navigation it is taken as elevation 455.5. The lift in either case is 42.8 feet. At extreme low water all the flow will be passed through the power house, leaving the surface of the water just level with the crest of the dam. This places the low water level 3.0 feet (for 9-foot navigation) above the upper level of Lock 7, Muscle Shoals Canal, neglecting the slope of the pool.

42. *Effect on United States grounds at Lock 6.*—If the length of the crest be assumed as 3,355 feet, allowing for space occupied by the power house and the lock, the depth on the crest at high water will be 13.8 feet, making the elevation of the surface at high water 469.3 for 9-foot navigation and 466.3 for 6-foot navigation. The corresponding low-water elevations are 455.5 and 452.5, respectively.

Using Poiree's backwater formula:

$$D = H + L - ix + \frac{(ix)^2}{4H}$$

in which D = new depth at point considered;
H = increased depth at dam;
L = original depth at point considered, and also at dam, since depth is considered uniform;
ix = total fall in distance considered;

from which we have:

$$\text{Backwater} = \frac{(2H - ix)^2}{4H};$$

we obtain the following elevations of low and high water at Lock 6:

	6-foot navigation.	9-foot navigation.
Low water	464.7	466.7
High water	475.7	479.0

It seems reasonable to cast considerable doubt on the conclusions drawn from the use of this formula, since it indicates a fall of about 11 feet in the pool at extreme low water. This is the equivalent of saying that at extreme low water we shall have a slope of 1.7 feet per mile in the upper pool, which is not borne out by observed slopes in similar pools. Nor is it reasonable to suppose; for, let us assume that 2 feet of this fall is at the dam and the remaining 9 feet uniformly distributed over the pool. We have then a surface slope of 1.4 feet per mile. The width at Resting Island is 6,000 feet approximately, and the depth, from this formula, would be about 20 feet. Let us assume that the coefficient of roughness is equal to 0.03 (probably greater than actually exists). Take the Chezy formula:

$$V = C\sqrt{RS},$$

in which V = velocity;
C = a coefficient;
R = hydraulic mean radius;
S = slope.

But $V = \frac{Q}{A}$ (flow ÷ area of cross section); and R = approximately D (mean depth);

whence $Q = AC\sqrt{DS}$.

Using n = 0.03 (very high value), we have $C = 82 +$.

By hypothesis, A = 120,000;
D = 20;
S = .0003.

Whence Q = 788,000 cubic feet per second, which indicates the values obtained by the Poiree formula to be wrong, since the low-water flow does not exceed 10,000 cubic feet per second.

Nor is this much improved if we assume all but the upper 10 feet of water to be a storage reservoir not in motion; which would give a volume flowing of 238,000 cubic feet per second. For sections where R is greater the discrepancy becomes greater.

Similarly for high water, the results from Poiree's formula would indicate a flow of 8,700,000 cubic feet per second, whereas the actual flow is about 508,000 cubic feet per second.

The results obtained by the Chezy formula indicate that in each case the results obtained by the Poiree formula are much too great. Assuming low-water flow = 10,000 cubic feet per second, and working backward from the Chezy formula, we have $S = \frac{1}{361^2}$, which indicates that the slope will be particularly nil. Again, assuming high-water flow = 340,000 cubic feet per second, and working backward from the Chezy formula, we have $S = \frac{81}{C^2D}$, which corresponds very nearly to a back-water of 8 feet. The depth on the crest at this stage will be over 13 feet, making a total backwater of 21 feet.

The conclusion seems inevitable that we can not predict with any degree of certainty the effects of the backwater. The true values probably lie some-

where between those which would be deduced by the Poiree formula and those indicated by the results from the Chezy formula. We know that backwater does exist. It may be that the reservoir action of the pool affects the application of the Chezy formula; and, since there is an undoubted movement of all the water in the pool, that the reservoir action may have an effect equivalent to an extraordinarily high value of the coefficient of roughness. There are not enough data, however, to determine what value should be assumed for the coefficient of roughness in Kutter's formula to check the results of the Poiree formula by that of Chezy.

We may, at least, safely say that no greater damage will occur than is indicated by the results of the application of the Poiree formula. These indicate that high water at Lock 6 will be at elevation 479. The upper pool of Lock 6 is at elevation 465.47. High water will then be 13.53 feet above the upper pool of Lock 6. This will flood out the present shop and dry dock and the low ground, but will not affect the high ground at the lock.

This requires the removal of the shops and dry dock to higher ground. The present shop arrangement is not good, and it will really be advantageous to move the shops. Excellent locations for them exist on the high ground just above Lock 6. This high ground is crossed by a small ravine which forms a natural location for a dry dock. The following arrangement can be made, from upstream down: (1) timber yard; (2) sawmill; (3) dry kiln; (4) wood-working shop; (5) lumber store yard; (6) shipyard; (7) dry dock; (8) shipyard; (9) machine shops; (10) machine storehouse; (11) foundry; (12) scrap yard; so that every piece when finished would be nearest its point of use.

The water power which now operates the sawmill and wood-working shop would be destroyed.

The most expensive single item of the change will be the new dry dock. The flood range will be 23.5 feet. If we allow 9 feet on the miter sill and 5.5 feet in height of gates for safety, the gates will be 38 feet high and cost about $85,000. Pumping and operating machinery and valves would be required, as well as the construction of dock. The total is estimated at $175,000. Allowing $125,000 for the rebuilding of the shops and all other damages, the necessary changes will amount to $300,000.

43. *The Dam.*—The average elevation of rock is about 404.5 along the line of the dam. The natural rock is a hard, flinty limestone, which will probably offer considerable resistance to the scouring action of the wave below the toe. The native limestone used in the culverts at Muscle Shoals Canal has abraded considerably under the comparatively low heads and clear water of the canal. While the rock found at the site of the dam is reported as being a better resistant to abrasion, it seems best to proceed cautiously in placing a dam with 40 feet overfall on a limestone foundation. If the water were to strike with its full force, each cubic foot would give an impact greater than 1 foot-ton. Some of this will no doubt be lost on account of the shape of the dam and on account of friction against the dam. At the Spier Falls dam on the Hudson, which has a lift of 40 feet, 3 feet on the crest give 1 foot on the apron, and a great deal of the water is churned into spray. Under these conditions the native rock may offer sufficient resistance. On the other hand, the Tennessee River carries much coarse material, and every crack, seam, and crevice below the dam will be thoroughly searched by the scouring action. If any weak place is found, the attack may result in a repetition of the conditions which caused the failure of the Austin dam. In the absence of special tests to determine the resistance of the natural bed rock, it seems only reasonable to provide for an extensive apron below the dam.

This apron is made of large blocks of granite closely bedded in concrete. To provide against these stones being carried out if the concrete around them erodes to any marked extent, no stone weighing less than 2 tons should be used. To insure covering the entire width of the wave below the dam, the apron is made 300 feet wide. Repairs to this apron will be very difficult to make, and possible of execution only at very low stages. The Tennessee carries large quantities of heavy drift, which will attack the apron. There are instances on record where this action has been carried on until holes 2 feet in depth were made in solid concrete. To provide against this the apron is given a maximum thickness of 6 feet and a minimum thickness of 2 feet. The apron should not be set on a poor foundation. To provide for a good foundation—in the absence of definite data—the apron is set 2 feet into the native bed rock. The apron is made 6 feet thick at the dam and 2 feet thick at its downstream edge, with a uniform slope to its top surface.

Two dams are figured for the consideration of the Board: One with its crest at elevation 452.5 for 6-foot navigation and the other with its crest at 455 for 9-foot navigation. The front slope is made 8¼ vertical to 10 horizontal, to give a high factor of safety.

44. *Calculations for dam, 6-foot navigation.*—Using the formula for weir discharge:

$$H^3 = \frac{(Q)^2}{L\ M\ 8.03}$$

and taking Q as given below, L equal to 3.355 feet at elevation 452.5, and M equal to 0.37, we deduce the following table:

Stage on Florence gauge.	Discharge.[a]	Interpolated elevation of lower pool.	Calculated depth on crest of dam.	Overturning moment.		Net overturning moment.[b]
				Upper pool.[b]	Lower pool.[b]	
Feet.		*Feet.*	*Feet.*			
0.0	10	407.0	1.0	1,224	.....	1,224
3.1	37	409.3	2.4	1,325	.....	1,325
6.2	69	411.6	3.6	1,411	.....	1,411
9.3	103	413.9	4.8	1,498	3	1,495
12.4	150	416.2	6.1	1,584	6	1,578
15.5	200	418.5	7.4	1,685	14	1,671
18.6	250	420.8	8.6	1,771	23	1,748
24.8	360	425.4	10.9	1,944	55	1,889
32.5	508	431.0	13.8	2,146	148	1,998

[a] Thousands of cubic feet per second.
[b] Thousands of foot-pounds.

From which we see that the maximum overturning moment will be at extreme high water.

Assuming a dam 8 feet at top, 48 feet above rock, and set 4 feet into rock, back vertical, front slope 8¼:10; width where slope intersects base at rock, 48 feet, we have that its net resisting moment about its lower toe is 5,949,440 foot-pounds, giving a factor of safety of 2.98, neglecting the pressure of the water on the face of the dam. The apron will connect with the dam by an arc of a circle whose radius is 40 feet.

45. *Calculations for dam, 9-foot navigation.*—By the same methods used in the preceding paragraph we have that the maximum net overturning moment will be 2,356,000 foot-pounds. Assuming a dam 8 feet on top, 51 feet above rock, and set 5 feet into rock, back vertical, front slope 8¼ to 10, base 50.5 feet, we have that its net resisting moment to rotation about its lower toe is 6,975,780 foot-pounds, giving a factor of safety of 2.96. The apron will connect with the front slope of the dam by an arc of a circle whose radius is 40 feet.

46. *Guard of the lock.*—The dam will never drown out, and navigation is supposed to be continuous. The lock must therefore have such a guard as will insure its operation at all stages. The maximum calculated depth on the crest of the dam is 13.8 feet. For safety the guard of the lock is made 15.5 feet. This places the top of the lock walls at elevation 468 for 6-foot navigation and at 471 for 9-foot navigation.

47. *Plan of the lock.*—The lock is taken as 800 feet between hollow quoins, buttresses 100 feet, upper guard and guide walls 800 feet above the upper buttresses, lower guard and guide walls 400 feet below the lower buttresses. This affords a head bay slightly greater than the lock chamber, and gives protection to vessels and tows for 1,200 feet below the toe of the dam.

48. *Lock walls for 6-foot navigation.*—A summary only of the calculations for these walls is given here.

(a) *River curtain wall.*

Worst condition: Water inside at elevation 466.3; water outside at elevation 431.

Net overturning moment, 2,542,000 foot-pounds.

Section of wall: 12-foot top, 45-foot base, 66 feet high.

Resisting moment, 7,678,440 foot-pounds.

Factor of safety, 3.02.

(b) *Land curtain wall.*

Worst condition: Lock empty, earth backing in fluid condition.

Overturning moment, 1,507,000 foot-pounds.

Section of wall same as river curtain wall.
Resisting moment, 4,172,000 foot-pounds.
Factor of safety, 2.77, verticle earth pressure neglected; or 5.74, considering vertical earth pressure.
(c) *Buttresses.*
Weakest: Lower river buttress.
Worst condition: Water inside at elevation 466.3; water outside at elevation 431.
Assumption: Entire gate thrust uniformly distributed over and taken up by 25 feet of wall.
Maximum net overturning moment, 6,030,000 foot-pounds.
Section of wall: 28-foot top, 64-foot base, 66 feet high.
Resisting moment, 16,928,000 foot-pounds.
Factor of safety, 2.81.
(d) *Coffer and miter walls.*
The quantities in these are about balanced by the quantities omitted in the culverts. No estimate, therefore, is made for them.
49. *Lock walls for 9-foot navigation.*
(a) *River curtain wall.*
Worst condition: Water inside at elevation 469.3; water outside at elevation 431.
Net overturning moment, 2,922,000 foot-pounds.
Section of wall: 12-foot top, 47-foot base, 69 feet high.
Resisting moment, 8,695,540 foot-pounds.
Factor of safety, 2.98.
(b) *Land curtain wall.*
Most unfavorable case: Lock empty, earth backing in fluid condition.
Net overturning moment, 1,723,000 foot-pounds.
Section of wall same as river curtain wall.
Resisting moment, 4,695,000 foot-pounds.
Factor of safety, 2.725, vertical earth pressure neglected; or 4.098, vertical earth pressure considered.
(c) *Buttresses.*
Weakest: Lower river buttress.
Worst condition: Water inside at elevation 469.3; outside at 431.
Assumption: Entire gate thrust uniformly distributed over and taken up by 25 feet of wall.
Maximum net overturning moment, 6,931,000 foot-pounds.
Section of wall: 28-foot top, 70-foot base, 69 feet high.
Resisting moment, 19,758,000 foot-pounds.
Factor of safety, 3.0.
(d) *Coffer and miter walls.*
The quantities in these are about balanced by the quantities omitted in the culverts. No estimate, therefore, is made for these.
50. *Factor of safety, etc.*—In all this construction the factor of safety has been taken at from 2.8 to 3.0 for masonry. For works of less magnitude a factor of safety of 2.0 to 2.5 for masonry would probably suffice. In the complete canalization of rivers in the United States this series of locks and dams has no parallel from which to draw any premises as to factors of safety. To insure the stability of the works a rather large factor of safety has been selected. The failure of any of these works would be followed by such great loss of property, if not also of life, that it is considered prudent to use a factor of safety larger than that ordinarily employed. For comparison there are submitted the designs at Hales bar and the designs of the Muscle Shoals Hydro-Electric Power Company, which were copied from Hales bar apparently without considering the change in conditions.

River curtain wall.

Project.	Dimensions.			Factor of safety.
	Height.	Top.	Base.	
Muscle shoals:	*Feet.*	*Feet.*	*Feet.*	
9-foot navigation	69	12	47	2.98
6-foot navigation	66	12	45	3.02
Hales bar	58	8	36	2.18
Muscle Shoals Hydro-Electric Power Co	56	8	36	1.84

Land curtain wall.

Project.	Dimensions.			Factor of safety.
	Height.	Top.	Base.	
	Feet.	*Feet.*	*Feet.*	
Muscle shoals:				
9-foot navigation	60	12	47	2.75
6-foot navigation	66	12	45	2.77
Hales bar	58	5	34	2.22
Muscle Shoals Hydro-Electric Power Co	56	8	36	2.02

Lower river buttress.

Muscle shoals:				
9-foot navigation	60	28	68	2.88
6-foot navigation	66	28	64	2.81
Hales bar	58	22½	46½	2.01
Muscle Shoals Hydro-Electric Power Co	56	22½	51½	1.90

51. *Lining of culverts and floor.*—With locks of this lift it is not considered advisable to leave the culverts unlined. The results obtained from the operation of locks at Muscle Shoals Canal show that fairly clear water under relatively moderate heads will erode the native limestone quite sharply and cement mortar about 2 inches less. The erosion of concrete would be somewhere between that of limestone and that of cement mortar. In this connection we must also consider that these locks will be exposed to the scouring action of sand and gravel carried along at about eight times the speed of flow in the locks of Muscle Shoals Canal. The conclusion seems inevitable that unless the culverts are lined serious scour will result. In order to fill or empty the lock in two minutes, the culverts are made of two arched sections, 12 feet vertical by 8 feet horizontal. This is arrived at as follows:

$$T=\frac{2A\sqrt{H}}{Ca\sqrt{2g}},$$

in which T=time in seconds:

A=horizontal area of chamber;

H=head:

C=a coefficient, taken here as 0.6:

a=area of culvert, which in this case is 174 square feet for the two culverts, or 87 square feet for each.

Taking H=45 feet and A=72,000 square feet, T=19 minutes 11 seconds.

The great size of castings, if made singly, and the difficulty of placing them accurately if made in sections, as well as their great cost, make cast iron less favorable than vitrified brick for lining the culverts. Approximately 700,000 brick will be required for the purpose.

The space between the lift and coffer walls, the chamber, and the upper portion of the tail bay will also be exposed to this great scour. Asst. Engineer W. S. Winn, who has examined these lock sites, states that the natural rock there offers much better resistance to abrasion than the stone used in the locks at Muscle Shoals Canal. It seems advisable, however, to provide for undoubted safety; and in the absence of specific test of the resisting qualities of the natural rock to provide for lining the portions of the lock mentioned (300 feet in tail bay) with vitrified brick. For this purpose 470,000 vitrified brick will be required. After specific test are made it may be found possible to omit this item, but it is believed best to include it in the estimate.

52. *Abutment.*—The abutment will be made by cutting into the solid natural rock, past any seams which reach the face, and keying the dam therein. In the absence of any detailed examination it is assumed that 50 feet will be ample to provide for this connection.

53. *Earth excavation.*—Along the line of the dam excavation will have to be made through Pattons Island, Jackson Island, and a towhead. There will be very little earth excavation at the lock site. The abutment will require a small amount of earth excavation. The total quantity is estimated at 72,000 cubic yards.

54. *Rock excavation.*—This will occur under the entire structure, and at the third lock of the series, where the heaviest rock excavation will be required. It is best to include this last item under the work for this lock, since if it is not done simultaneously with the construction of this lock the cost of removal will be very much greater after the pool is over the site. The total amount

of this work is estimated at 270,000 cubic yards for 6-foot navigation and 278,000 cubic yards for 9-foot navigation, since the dam for the latter project is set 5 feet into the rock, while for 6-foot navigation the dam is set only 4 feet into the rock.

55. *Cofferdam.*—The same form of cofferdam is proposed as for the Florence lock. If built simultaneously with the Florence lock its height can be the same, and the cost per linear foot will be the same. If built after the Florence lock is built it will have to be correspondingly higher, and its cost will be increased 50 per cent. For purposes of estimate it is assumed that this lock and dam will be built simultaneously with the one at Florence. The increased cost should, however, be borne in mind in case the Florence lock is built first. The Florence lock could not well be built later than these works, since until the Florence lock and dam are built these works would form a complete bar to navigation.

56. *Concrete.*—The quantities are:

	Cubic yards.
(a) For 6-foot navigation:	
In the dam and abutment	237,000
In the lock	324,000
Total	561,000
(b) For 9-foot navigation:	
In the dam and abutment	278,000
In the lock	350,000
Total	628,000

57. *Paving.*—The terreplein of the lock and all natural banks, other than solid rock or when protected by the lock, are protected by paving, and the estimate is made on this basis. This is a rather crude estimate, but it is about as close as can be made in the absence of detailed information and still keep on the safe side as to cost. It is believed that after a detailed survey is made it will be found possible to reduce considerably this paving, if indeed not to omit it entirely, except in the terreplein of the lock, since the lock and abutment, being situated next to rock bluffs, are perfectly safe from being cut around, regardles of the scour of the earth banks below the dam, and since any land that would be scoured away would probably have to be purchased on account of overflow from the Florence dam. On the other hand, if the detailed survey should show that there are soft natural banks to be preserved, this estimate is rather low, since there would probably have to be constructed a concrete toe to prevent the scour from undermining the paving at its toe—a condition that is now being similarly met in a work under the charge of this office. The map and observations indicate that a portion of this protection will probably not be needed; but the estimate is believed to be as close as can be safely made without the aid of a detailed survey.

The distance below the dam that the protection should be carried is a difficult question to determine. In the absence of more definite information, provision is made for protecting the banks 100 feet for each foot of fall.

The amount of paving estimated for this purpose—using the natural slope of banks—is 21,000 square yards, to cover 3,000 feet. The amount of riprap required is 7,000 square yards.

58. *Land.*—It is assumed that 20 acres will be necessary for the lock site and 10 acres for the abutment. The submerged lands (scaled from the map) amount to 1,175 acres, making a total of 1,205 acres. For the same reasons as given in the discussion of the lock and dam at Florence, this is arbitrarily increased to 1,500 acres.

59. *Lock gates.*—Using the gates at Hales bar for purposes of comparison, the cost of this item will be:

(a) For 6-foot navigation:	
Upper gates	$30,750
Lower gates	100,160
	130,910
Add 33⅓ per cent for possible increase in price of steel	43,637
Total	174,547
Estimate	175,000

(b) For 9-foot navigation:

Upper gates	$37,900
Lower gates	160,000
	197,900
Add 33⅓ per cent for possible increase in price of steel	65,967
Total	263,867
Estimate	264,000

60. *Lock machinery.*—On the same basis the cost of the lock machinery will be $25,000.

61. *Lock houses.*—This item is arbitrarily assumed at $10,000.

62. *Cost of 6-foot project—*

Concrete, 561,000 cubic yards, at $7	$3,927,000
Earth excavation, 72,000 cubic yards, at $0.75	54,000
Rock excavation, 541,000 cubic yards, at $3	1,623,000
Back fill, 140,000 cubic yards, at $0.75	105,000
Cofferdam, 8,000 linear feet, at $22	176,000
Paving, 21,000 square yards, at $2	42,000
Riprap, 7,000 square yards, at $1	7,000
Vitrified brick, 1,170 M, at $16	18,720
Lock gates	175,000
Lock machinery	25,000
Lock houses	10,000
Land, 1,500 acres, at $100	150,000
	6,312,720
Contingencies, etc., 20 per cent	1,262,544
Estimated total cost	7,575,264

63. *Cost of 9-foot project—*

Concrete, 628,000 cubic yards, at $7	$4,396,000
Earth excavation, 72,000 cubic yards, at $0.75	54,000
Rock excavation, 595,000 cubic yards, at $3	1,785,000
Back fill, 140,000 cubic yards, at $0.75	105,000
Cofferdam, 8,000 running feet, at $22	176,000
Paving, 21,000 square yards, at $2	42,000
Riprap, 7,000 cubic yards, at $1	7,000
Vitrified brick, 1,170 M, at $16	18,720
Lock gates	264,000
Lock machinery	25,000
Lock houses	10,000
Land, 1,500 acres at $100	150,000
	7,032,720
Contingencies, etc., 20 per cent	1,406,544
Estimated total cost	8,439,264

64. *Memoranda for use of Board in considering project—*

(A) FLORENCE LOCK AND DAM.

Average saving for each foot reduction in height of lock walls, main lock	$26,610
Average saving for each foot reduction in height of lock wall, Florence lock	14,157
Average saving for each foot reduction in width of main lock	4,700
Average saving for each foot reduction in length of lock chamber, main lock	404
Average saving for each foot reduction in length of head bay, main lock	360
Average saving for each foot of bank left unpaved below main lock	14
Average saving for each foot of bank left unpaved on Florence side	8

(B) LOCK AND DAM AT HEAD OF PATTONS ISLAND (6-FOOT PROJECT).

Average saving for each foot reduction in height of lock walls	$42,972
Average saving for each foot reduction in width of lock	7,466
Average saving of each foot reduction in length of lock chamber	1,158
Average saving for each foot reduction in length of tail bay	1,158
Average saving for each foot reduction in length of head bay	950
Average saving for each foot of paving omitted	14
Average saving for each foot of paving replaced by riprap	7
Additional cost of 6-foot toe wall of concrete along paved bank, per running foot	8
Average saving for each foot of apron omitted	2,700
Saving due to not paving lock chamber and head and tail bays with brick	7,520
Saving due to not lining culverts	11,200
Saving due to reducing factor of safety from 2.8–3.0 to 1.8–2.0 (Lock, $491,322; dam, $222,225.)	713,547

(C) LOCK AND DAM AT HEAD OF PATTONS ISLAND (9-FOOT PROJECT).

Average saving for each foot reduction in height of lock walls	$46,987
Average saving for each foot reduction in width of lock	11,265
Average saving for each foot reduction in length of lock chamber	1,248
Average saving for each foot reduction in length of head bay	1,022
Average saving for each foot reduction in length of tail bay	1,248
Saving due to reducing factor of safety from 2.8–3.0 to 1.8–2.0	779,670

Lock	$390,780	
Dam	388,890	
		$779,670

In all the foregoing no account has been taken of 20 per cent addition for contingencies. If this be reckoned in, it will increase all the above amounts by 20 per cent.

LOCK AND DAM AT RESTING ISLAND.

65. *Location.*—It is assumed that this lock and dam will be located essentially as proposed by the Muscle Shoals Hydro-Electric Power Company. The right bank offers the better location for the lock, and a passage from the left bank to the right bank can be readily effected in the upper pool of the Pattons Island dam.

66. *The dam.*—The crest of the dam is assumed at elevation 492.5 for 6-foot navigation, or at 495.5 for 9-foot navigation. The crest scales 6,533 feet, as shown on the blueprint. However, it is considered better to set the lock back against the natural bank than to locate it as proposed by the Hydro-Electric Company, and to allow 50 feet for any rotten or seamy rock found on the abutment side. These changes will make the length about 6,700 feet. The depth on the crest is computed at 9.2 feet for extreme high water, allowing for a power house 600 feet long.

67. *Similarity to the Pattons Island lock and dam.*—In plan, except for the length of dam and apron, this dam will be identical with that at Pattons Island. The lift is also practically the same. The guard may be reduced 3 feet, but to save time in the preparation of this project, the cross sections of lock walls, apron, and dam are assumed to be identical with those at Pattons Island. The same lining is given to the culverts, and the lock pit is paved in the same manner. The abutment will also be in solid rock. Only the quantities which differ will therefore be given special consideration.

68. *Earth excavation.*—The dam crosses Walkers and near Resting Islands; the abutment will require some earth excavation; and the lock will require excavation of the towpath and bed of Muscle Shoals Canal. The total of this work is estimated at 250,000 cubic yards.

69. *Back fill.*—It is estimated that all back fill can be made from material excavated, and no separate allowance is made for this item.

70. *Rock excavation.*—The excavation for the approach to this lock has been previously estimated under the Pattons Island dam. (See paragraph 54.) The additional excavation of this class is estimated as follows: Under the dam, 35,000 cubic yards; under the lock, 9,000 cubic yards; under the abutment, 6,000 cubic yards; and for the approach to the next lock of the series, 10,000 cubic yards; making 60,000 cubic yards in all. In each case the excavation for the approach to any lock is considered as part of the work on the lock below, since

Rock excavation, 595,000 cubic yards, at $3	1,758,000

it is much cheaper to remove this in the natural shallow river than when i a deep pool over it. Under the apron it is 271,000 cubic yards.

71. *Cofferdams.*—These are assumed of the same dimensions as for the ence lock. (See p. 15.) If this lock is built simultaneously with the lo Pattons Island, the height of cofferdam can be reduced materially and the about one-third. About 14,500 linear feet of cofferdam will be required.

72. *Land.*—For the lock and abutment 30 acres are required. Along the bank 160 acres, exclusive of the Bluewater Creek bottom, and along the bank 120 acres, exclusive of the Town Creek bottom, will be flooded. Th lowing islands will be drowned out: Coffee, 20 acres; Harrys, 10 acres; E 20 acres; Cedar, 25 acres; Cox, 200 acres; Sister Islands, (2), 50 acres; Tu Chute, 20 acres; Walkers, 150 acres; Resting, 130 acres; not named, 10 a total, 635 acres. It is impracticable to estimate the bottoms of Bluewate Town creeks, as the map does not show their extent. An allowance of 200 is made for the first and 355 acres for the second, bringing the total land merged to 1,500 acres. As a good deal of this land can be had for $50 per if we estimate $100 per acre for the total stated we shall probably cover the of any excess of land submerged over that estimated.

73. *Cost for 6-foot project—*

Concrete, 720,682 cubic yards, at $7	$5,04
Earth excavation, 250,000 cubic yards, at $0.75	18
Rock excavation, 331,000 cubic yards, at $3	99
Paving, 21,000 square yards, at $2	4
Riprap, 7,000 square yards, at $1	
Cofferdam, 14,500 running feet, at $22	31
Vitrified brick, 1,170 M, at $16	1
Lock gates	17
Lock machinery	2
Lock houses	1
Land, 1,500 acres, at $100	15
	6,97
Contingencies, etc., 20 per cent	1,39
Estimated total cost	8,36

74. *Cost for 9-foot project—*

Concrete, 794,756 cubic yards, at $7	$5,56
Earth excavation, 250,000 cubic yards, at $0.75	18
Rock excavation, 331,000 cubic yards, at $3	99
Paving, 21,000 square yards, at $2	4
Riprap, 7,000 square yards, at $1	
Cofferdam, 14,500 running feet, at $22	31
Vitrified brick, 1,170 M, at $16	1
Lock gates	26
Lock machinery	2
Lock houses	1
Land, 1,500 acres, at $100	15
	7,57
Contingencies, etc	1,51
Estimated total cost	9,09

75. *Notes for use of board in considering project.—*

	Lock and dam at R Island.	
	6-foot navi-gation.	9-foot gat
Saving due to reducing guard of lock 2.0 feet	$88,821	
Saving due to reducing width of apron 1.0 foot	5,625	

Otherwise the notes under the Pattons Island dam will apply. (See graph 64.) The 20 per cent allowance for contingencies is not included i above.

LOCK AND DAM NEAR SECOND CREEK.

78. *Location.*—It is assumed that this lock and dam will be located essentially as proposed by the Muscle Shoals Hydro-Electric Power Company, except that the lock will be moved in near the right bank.

79. *The dam.*—The greatest elevation of the river bed between Lock A and the head of Browns Island is 527, just below Mallard Creek. This places the crest of the dam at elevation 533 for 6-foot navigation, or 536 for 9-foot navigation. This is 40.5 feet above the crest of the next dam below. The length of crest is 5,800 feet. The calculated maximum depth on the crest will be 10.3 feet, allowing 600 feet of crest for power house.

80. *Similarity to works below.*—In plan, except for the length of dam and apron, this structure will be practically identical with the dam at Pattons Island. The lift is practically the same. The same lining is given to the culverts, and the lock pit is paved in the same manner. The abutment will probably be in solid rock. The height of the dam for 6-foot navigation will be 46 feet above rock and set 4 feet into the rock; for 9-foot navigation these dimensions will be 49 feet and 5 feet, respectively. The height of the lock walls is made 62 feet above rock for 6-foot navigation and 65 feet for 9-foot navigation. The curtain walls are 12 feet on top; the base width is 39 feet for 6-foot navigation and 41 feet for 9-foot navigation. The buttresses are 28 feet on top; their base width is 57 feet for 6-foot and 61 feet for 9-foot navigation.

81. *Earth excavation.*—There will be practically no earth excavation for the dam; but for the abutment there will be a little, and the wing walls of the lock will require excavation of the towpath and bed of Muscle Shoals Canal. The total is estimated at 5,000 cubic yards.

82. *Back fill.*—The amount of fill behind the lock walls is estimated at 130,000 cubic yards for 6-foot navigation and 140,000 cubic yards for 9-foot navigation.

83. *Rock excavation.*—The rock excavation necessary under the lock is taken as 9,000 cubic yards; that under the dam as 35,000 cubic yards; and that for the abut ment as 1,000 cubic yards, making a total of 45,000 cubic yards exclusive of the apron, which amounts to 258,000 cubic yards.

84. *Cofferdam.*—This is assumed of the same cross section as for the other locks. About 14,000 linear feet will be required.

85. *Land.*—For the lock and abutment 30 acres are required. The following islands will be drowned out, the figures in parentheses indicating the number of acres in each: Tick (500), Gourd (20), Sweetgum (35), Weaver (75), Howard (40), Gilchrist (420), Corn (25), Sedgegrass (75), Poplar Tree Slough (2,000); total, 3,190 acres. On the right bank it is estimated that there will be submerged at least 1,600 acres, and on the left bank 2,600 acres. This does not include the bottoms of Elk River, nor of those on the left bank opposite Gilchrist Island. It is impossible to estimate these, as their extent is not shown on the map. An allowance of 1,610 acres is made for them, bringing the total land to be submerged to 9,000 acres. On account of the great uncertainty existing as to the exact amount of land that will be overflowed, and on account of the certainty that a great deal will be overflowed, it is considered advisable to arbitrarily raise the estimate for this item to 15,000 acres.

86. *Cost for 6-foot navigation—*

Concrete, 596,000 cubic yards, at $7	$4,172,000
Rock excavation, 303,000 cubic yards, at $3	909,000
Earth excavation, 5,000 cubic yards, at $0.75	3,750
Back fill, 130,000 cubic yards, at $0.75	97,500
Cofferdam, 14,000 running feet, at $22	308,000
Paving, 21,000 square yards, at $2	42,000
Riprap, 7,000 square yards, at $1	7,000
Vitrified brick, 1,170 M, at $16	18,720
Lock gates	175,000
Lock machinery	25,000
Lock houses	10,000
Land, 15,000 acres, at $100	1,500,000
	7,267. . .0
Contingencies, etc., 20 per cent	1,453,594
Estimated total cost	8,721,564

87. *Cost for 9-foot navigation—*

Concrete, 663,000 cubic yards, at $7	$4,641,000
Rock excavation, 303,000 cubic yards, at $3	909,000
Earth excavation, 5,000 cubic yards, at $0.75	3,750
Back fill, 130,000 cubic yards, at $0.75	97,500
Cofferdam, 14,000 running feet, at $22	308,000
Paving, 21,000 square yards, at $2	42,000
Riprap, 7,000 square yards, at $1	7,000
Vitrified brick, 1,170 M, at $16	18,720
Lock gates	264,000
Lock machinery	25,000
Lock houses	10,000
Land, 15,000 acres, at $100	1,500,000
	7,825,970
Contingencies, etc., 20 per cent	1,565,194
Estimated total cost	9,391,164

83½-FOOT LIFT LOCK AND DAM AT RESTING ISLAND.

88. *Reasons for submitting.*—The river and harbor act of March 2, 1907, directs the Board to consider the improvement of this section "by not to exceed three locks and dams." The site of one of these has already been located, in this project, at Florence and that of another at the head of Pattons Island. The third will have to be located at the site of the dam proposed at Resting Island, and if no provision be made for a fourth will necessarily have a lift equal to the combined lifts of that lock and the one proposed near Second Creek.

89. *The dam.*—The crest of the dam will be at elevation 536. The greatest calculated depth on the crest will be 9.2 feet, making the elevation of high water 545.2. The old elevation of high water is 467. The dam is taken as 8 feet on top, 78 feet on base at rock, set 10 feet into rock. This gives a factor of safety of 3.02. The contents of the dam are 1,030,260 cubic yards. The apron will extend 600 feet below the dam and be 12 feet thick at its upper edge, 4 feet thick at its lower edge, and set 4 feet into rock. It joins the dam by the arc of a circle whose radius is 80 feet. Its contents are 1,066,700 cubic yards. About 800,000 cubic yards of rock excavation and 19,200 running feet of cofferdam will be required, in addition to 92,000 cubic yards of earth excavation. The abutment is assumed to be made by keying the dam into the natural solid rock bluff. The cost of the dam alone will be about $17,570,120, or nearly as much as the entire cost of the two locks and dams proposed.

90. *Hydraulic lift lock.*—In complete canalization this would have to be set between walls to keep out the wash and draw of the dam. Probably 900 feet will suffice above the dam, but below it the protection should be extended at least 3,000 feet, since the energy remaining in the overfall will be twice as great as that remaining in the overfall of dams for which 1,500 feet protection is provided. This requires 1,058,896 cubic yards of concrete, 52,000 cubic yards of rock excavation, 780,000 cubic yards of back fill, and 5,000 running feet of cofferdam, costing, all told, $8,255,272. The largest lift of this kind is at Peterborough, Canada, and is 65 feet, with caissons 140 by 33 by 8 feet. According to Prussman such a lock will cost $590,000. If we increase the chambers to 800 by 90 by 10 feet, the cost will run up to about $10,000,000 for an 83½-foot lift. This makes the total cost $18,255,000.

91. *Other items and estimate.*—The necessary paving and bank protection are estimated at $50,000 and the lock houses at $10,000. We have then for the cost—

Dam	$17,570,120
Lock	18,255,000
Overflowed land (20,000 acres)	2,000,000
Minor items	60,000
	37,885,120
Contingencies, etc., 20 per cent	7,577,024
Estimated total cost	45,462,144

92. *Mitering gate lock.*—The summaries of sections only are given here.
Curtain walls: 12-foot top, 61-foot base; factor of safety, 3.07.
Buttresses: 28-foot top, 80-foot base; factor of safety, 3.02.
The cost of the lock without gate will be $8,350,000. The gates will cost, complete with operating machinery, about $960,000.

93. *Estimated cost—*

Dam	$17,570,120
Lock	9,310,000
Land	2,000,000
Minor items	60,000
	28,940,120
Contingencies, etc., 20 per cent	5,788,024
Estimated total cost	34,728,144

94. *Remarks.*—The results in price as between hydraulic lift and mitering gate locks were a little startling. The discussion was started on the assumption that the hydraulic lift lock would be the cheaper.
Asst. Engineer John M. G. Watt has translated parts of a German work presented by Prussman to the Permanent Association of Navigation Congresses in 1905. Herr Prussman gives a rigorous discussion of the practicable lifts of the various classes of locks. He concludes that 65 feet (20 meters) is the limit of economy for hydraulic lifts, and 49 feet (14.9 meters) for mitering gate locks.
The construction of this lock and dam is not recommended, as their cost is greater and their safety more questionable than two locks and dams covering the same stretch of river. For this reason only a brief synopsis of the general facts relative to this project is submitted, and no drawings have been prepared.
95. *Conclusion of premises.*—From the foregoing it is seen that it will be more economical to use four locks and dams than to use three. The difference in cost between a project for 9 feet and one for 6 feet is so much less than it would cost ever to alter the works later that it is best to adopt the 9-foot project at once. Throughout this work the preparation of estimates and designs has been hampered by the lack of a detailed survey. This has prevented the accurate determination of certain features of the project. Before work is entered upon a careful detailed survey and examination should be made. This should show accurately the foundations as determined by extensive borings, to insure that the surface rock is not underlaid by any strata of inferior material. It should show, further, all land included by the calculated highest water. The nature of the banks should be accurately shown. The extent and direction of the earth dam at Florence should be determined. Tests of the resistance of the natural rock to abrasion should be made. Before this matter is carried further, Congress would do wisely to appropriate $50,000 for a complete examination and survey, to collect all the data necessary for the complete design and estimate of the works and for the preparation of plans.
In the following paragraphs will be given the general outline of the project recommended. All of the foregoing which relates to the 9-foot project and is not hereinafter repeated is still to be considered an integral part of the project—as much so as that which is repeated.

THE PROJECT.

96. *Object.*—The object of this project is to provide for the permanent improvement of that section of the Tennessee River included between the head of Elk River shoals and the Florence Railway bridge, in conjunction with the development of the water power.
97. *Improvement projected.*—The improvement projected is to be made by a series of four dams and five locks.
The first dam will be located about 1,000 feet above the Florence Railway bridge, and will contain two locks. The one on the left bank will be given a guard sufficient to insure its operation at all times, and will be for the use of through traffic. The one on the right bank will be given a guard sufficient to insure its operation at all times when boats can not pass across Pattons Island

in the upper pool of the dam. The owners of the Florence Railway bridge be required to place a new draw span of 200 feet clear width between piers entirely over navigable water near the left bank, as shown on the draw The line connecting the center of the rest piers will be parallel to the axi the lock, and the rest piers will be so constructed as to cause any boat stri them to glance off.

The second dam and third lock will be located near the head of Pat Island, as shown on the drawings. The lock will be on the left bank, and provide for through traffic. In the location of this lock and the determina of its lift, it becomes necessary to sacrifice either the low ground at Loc Muscle Shoals Canal, or a portion of the city of Florence, or to build an e lock and dam. The first course is preferable for obvious reasons.

The third dam and fourth lock are located at Resting Island, with the on the right bank. There will be no difficulty in making the crossing in pool above the second dam.

The fourth dam and fifth lock are located near Second Creek, with the on the right bank.

In all cases an allowance of 600 feet of crest has been made for the inse of a power house.

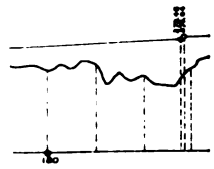
98. *Depth adopted.*—These works must be considered in the light of greatest future needs, and not in the light of present requirements. Whe this has not been done the result has uniformly been that the old works required removal, and larger works have had to be built at great expense. T works once installed may safely be said to be installed for all future t They must, then, provide for the greatest navigable depth the river sy will afford when improved throughout to the limit of its capacity. If weirs be installed of the bear-trap or Chittenden types which will regulate the levels absolutely, a system of movable dams in combination with high-lift p dams can be installed which will afford 9 feet minimum depth from the m of the Tennessee River to the mineral deposits of its tributaries. This pears to be about the limit possible. For movable dams the pools will ave in length about as follows: Paducah to Riverton, 43 miles; head of Col shoals to Florence, 11 miles; head of Elk River shoals to Hales bar, 27 mi above Chattanooga, 11 miles; Clinch River, 10 miles; French Broad River miles. The high-lift power dams would have pools of 12 to 22 miles. average length of pool may be taken at 15 miles for the system. Assumin speed of 5 miles per hour in the pools and allowing thirty minutes for a l age, we have an average speed of travel of slightly less than 4.3 miles hour. The low banks will not permit any greater lifts, even with movable d furnishing perfect regulation. This would force an increase in the numbe locks to give an increase in depth, and this in turn would reduce the speed travel until navigation would not be profitable.

Nine feet appears to be the limit of depth which the Tennessee River sys will ever afford, and is adopted for this project. The improvement of t river system for a navigable depth of 9 feet will probably not be underta during the lifetime of any of us; but it should be borne in mind that th works are expected to serve the needs of future generations as well as thos the present one.

99. *Size of locks.*—The four main locks are made 90 by 800 feet in the ch ber, to pass (at a reasonable rate of speed) the largest tow ever moved on inland waters of the United States. Except in the case of the Florence l the necessity for protection from the wash of the water falling over the d so extends the lower guard and guide walls that the chamber could be creased 400 feet in length without additional expense, by a corresponding duction in length of tail bay; and it may be advisable to do this.

Whatever modifications may hereafter be made in the project, the width the lock should not be decreased, nor should the dimensions of the head bay diminished. It is a comparatively simple matter to extend the walls do stream and make a larger lock, if the culverts are of sufficient capacity for ew length of chamber. An increase in width, however, would be practic ohibitive in cost for locks of the lift of those proposed and in the locati lected. Nor would the matter of extending the head bay of a lock in 50 f water be a thing to be lightly undertaken.

The small lock on the right bank at Florence is made of less dimensions, si t is expected to provide only for packets and small tows. The dimensions he present Muscle shoals lock, 300 by 60 feet in the chamber, will probably mple for all the traffic that will ever pass through this lock.



low of the river is ample for the largest lock proposed. At the lowest
ıe filling will require the flow of the river for 6.4 minutes. As nineteen
. and forty seconds are the calculated time of filling, it is evident that
ill be no disturbance of the upper pool level.
ock at Florence amounts in cost to about 1 per cent of the entire project,
ıuld be provided to care for the commerce of industries which will be
to spring up there when cheap power is available.
Factor of safety.—For works of this size the factor of safety should be
rge. The failure of one of these works would be followed almost cer-
ıy the failure of all those below it. The damage which would be done
sudden release of about 40,000,000,000 cubic feet of water passes the
of imagination. To provide against this no factor of safety less than 3
A heavy apron is provided below all dams except the Florence dam,
oughout no effort has been made in the design to cut down the cost
uch a reduction might raise any question as to the safety of the works.
Protection of works.—Save on the right bank at Florence, the locks and
ıts are keyed into the natural rock for 50 feet, making them practi-
oof against being cut around. If the arrangement given in the right
Florence does not prove sufficient, the direction of the axis should be
l to more upstream and the earth dam and core wall carried back to
. The crest of the dam is placed well above the reach of any past or
e high water.
ınks where there is liability of any important attack and the terrepleins
locks are paved. Beyond this protection, riprap is placed to overcome
ttacks. While this will probably suffice, a better construction would be
ide a 6-foot toe wall for all paving and riprap; but on account of the
s is only suggested, and it is not included in the estimate. In addition,
a grass is used on slopes not otherwise protected.
ıt in the locks at Florence, provision is made for lining the culverts with
brick and for paving the floors of the locks. It would be an improve-
do this also at the Florence locks.
Materials of construction.—Cyclopean concrete is used throughout. No
ss than a ton in weight should be bedded, and the stones should be
egular in shape, so that the final construction will be nearly a random
wall filled with and covered with concrete. To insure against injurious
n mixing and to provide against any ill effect from varying quantities
, a rather rich mixture (about 1 : 2½ : 5) should be used. Clean, sharp
ould be specified, and the use of crusher dust in lieu of sand should be
ly prohibited. The run of the crusher, however, could be accepted for
stone, when screened of all pieces over 2 inches in any dimension.
ining of culverts and floors will be with vitrified brick, set in 1:2
with headers and stretchers so distributed as to bind the courses to-
ınd give the whole a firm bond with the concrete.
ollow quoins and the miter sill contact pieces will be of cast steel.
provides only for a thoroughly strong construction, and makes no pro-
'or appeal to the æsthetic sense. The estimate is based on this con-
n, but it would be better to increase the cost somewhat and make a
:tion that will be beautiful as well as substantial. A glaring wall of
nearly half a mile long can scarcely be said to be a thing of beauty.
l be much better to cover the whole with a shell of faced stone, built
the concrete and thoroughly bonded to it by long headers. This will
re than the plain concrete, but it will look infinitely better, and the
pent on it would be well applied. Some change from pure commercial-
l some slight concession to beauty in construction are well worth all
ey they will require.
Cost.—This has been estimated as follows:

locks and dam	$2,880,420
Island lock and dam	8,439,264
Island lock and dam	9,095,414
Creek lock and dam	9,391,164
to United States shops, etc	300,000
Total	30,106,262

this we add the stone facing and additional protection recommended,
l cost of the project can be estimated at $32,000,000.

104. *Mode of construction.*—The work should be done by hired labor exclusively. The experience of a contract for similar work on this river has been very unsatisfactory.

105. *Conclusion.*—In conclusion it is desired to extend thanks to the president of the Board, Col. William T. Rossell, Corps of Engineers, for valuable suggestions in regard to costs and factor of safety, which suggestions have been embodied in this project; and to Asst. Engineer John M. G. Watt for much valuable aid in making and checking calculations and estimates and in the preparation of drawings.

Very respectfully, your obedient servant,

W. G. CAPLES,
First Lieut., Corps of Engineers, Recorder to Board.

Col. WM. T. ROSSELL,
Corps of Engineers, U. S. A., Cincinnati, Ohio.

APPENDIX No. 2.

PARTICIPATION BY THE UNITED STATES GOVERNMENT IN THE COST OF MUSCLE SHOALS IMPROVEMENTS NOT AN INSTANCE OF GOVERNMENT AID.

By FRANK S. WASHBURN,
President Muscle Shoals Hydro-Electric Power Company.

NASHVILLE, TENN., *June 11, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under amendment to the rivers and harbors bill, second session, Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals, on the Tennessee River, State of Alabama.

GENTLEMEN: Water power developments projected upon navigable rivers may be said to fall under five typical conditions.

First. Where there are no navigation improvements, but where the river either with or without navigation works, may be made navigable.

In this case, providing the river were formally declared to be "navigable" the Government would be interested in maintaining surveillance over any power project only to a degree necessary to insure no obstruction being placed in the way of later navigation improvements by which such works would be made either impracticable or more expensive than they otherwise would be. We believe this statement of the Government's proper attitude will not be contradicted by anyone. That it is accepted in official quarters is evidenced by the fact that General Mackenzie, Chief Engineer of the United States Army, in comments made April 4, 1905, in connection with legislation affecting water power development, makes the following statement:

"Regarding the proposition to empower the Secretary of War to authorize the use and development of water power at localities not improved by the United States, it should be borne in mind that natural water power—that is, power made available by the existence of natural falls and rapids in a river—is appurtenant to riparian ownership, and the right to use it is governed by State laws on the subject of private property. As above set forth, the Federal Government can regulate and control it only to such extent as may be necessary in the interest of navigation."

Secretary of War, Hon. William H. Taft, in a communication addressed to the President, expresses the following opinion:

"It is, of course, in the interest of the public that improvements of this kind (water power developments) should be encouraged, and in streams in which there has been no expenditure of money to create water power it does seem to me necessary to extend the policy of demanding compensation for such a special use of Government lands as this privilege involves."

Second. Where there are existing navigation works which will not be injuriously affected by the proposed power developments.

Under these circumstances the Government would ordinarily be entitled to some rental provided the power company made use of Government structures for storage, head, etc., in the development of power. It is a usually accepted principle that wherever the Government has expended money in the establishment of works on navigable streams, and thereby materially contributed to

on of power, that no one should be licensed to utilize such power unless
ernment is paid for the use of its structures. The amount to which the
ient is entitled would be determined by various considerations. It can
e contended, for instance, where a corporation desires to place a power
low a Government lock and dam across a navigable stream, projecting
or other conduit for conveying water to the power house, that the power
should pay to the Government the entire amount which the lock and
cost the Government. The following principle, expressed by the Presi-
t veto message to the Fifty-seventh Congress:
oes not seem right or just that this element of local value should be
way to private individuals of the vicinage, and at the same time the
f the whole country should be taxed for the local improvement," has
plementary principle, namely, that it would not be right or just to
ndividuals of the vicinage that the navigation works which are of value
ople of the whole country should be paid for in toto by the power com-
d presented as a gift to the Government. Bearing upon the degree of
nse to which the Government is entitled is the fact that the Govern-
ights upon any stream are limited to the regulation and protection of
on. Chief Engineer Alexander Mackenzie's comment made on April 4,
Congress, bearing on water power developments, is pertinent in this
on, and in part is as follows:
onnection with legislation of this kind careful consideration should be
the question of limitations of the power of the Federal Government
igable waters. By virtue of its power to regulate commerce Congress
rcise control over the navigable water of the United States, but only
tent necessary to protect, preserve, and improve free navigation. The
Government has no possessory title to the water flowing in navigable
nor to the land comprising their beds and shores, and hence Congress
it no absolute authority to anyone to use and occupy such water and
manufacturing and industrial purposes. The establishment, regula-
l control of manufacturing and industrial enterprises, as well as other
pertaining to the comfort, convenience, and prosperity of the people,
thin the powers of the States, and the Supreme Court of the United
olds that the authority of a State over navigable waters within its
and the shores and beds thereof, is plenary, subject only to such action
ress may take in the execution of its powers under the Constitution to
commerce among the several States."
uld seem that the just and proper relation between the Government and
er company is that each should bear a share of the cost of those struc-
ich are commonly valuable to navigation and to power development.
Where there are navigation works completed and in operation which
e disadvantageously affected by the proposed power improvements.
h an event it would seem proper that the power company should bear
nse of placing the navigation works in a condition as valuable to com-
e they were originally, and of the original cost of such part of those
s are an advantage to the development of power, the power company
ay a proportion. Neither these conditions nor others readily conceiv-
uld warrant taking the entire burden of cost of the navigation works
shoulders of the Government and placing it upon the power company.
1. Where navigation works, though needed, do not exist, and where
ctures for power development will serve well and economically to
navigation.
ically follows in this case from the principles evolved for the proper
it of the preceding cases that the Government should bear the expense
structures which are purely for navigation purposes and the power
should bear the expense of those things which are purely of advantage
evelopment of power, and that the Government and power company
should bear the expense of those structures which are of an advantage
ation as well as to power development.
Where there are existing navigation works unsuitable to modern
and future growth of commerce, and where the proposed plans of the
ompany include structures which will provide modern navigation

ve seen from the declaration of the Supreme Court that the Govern-
not prohibit any corporation from developing power upon a navigable
The Government can justly and properly exercise only such control
cessary to protect navigation. Subject to this, the power company

requires only the authority of the State, ownership of the lands and rig rights, or the power to condemn them. In all essential particulars be upon the proper relation of the National Government to power companie case is similar to the preceding one, in which navigation works, though n do not exist, and where the structure for power development will serve and economically to improve navigation.

The principles involved in the second case, namely, where there are ex navigation works which will not be injuriously affected, apply here with force. The principle of both parties sharing the cost of structure, which tribute to the advantage of both interests, is not altered by the fact that in the one case the Government had made the needed navigation improve prior to the arrival of the power company, that in the other the needed imp ments will be made coincidently with the construction of the works of the p company.

There is even a stronger reason in the case under discussion for the Go ment bearing the entire expense of the purely navigation works and a pr tion of the expense of the works which are common to navigation and p development, for here the Government is enabled to secure navigation vantage by a partial expenditure, while in the first instance it had to the entire expenditure with the faint possibility that at the end of many some portion of the original expenditure might chance to be returned and that probably after the interest account alone had equaled the ori expenditure.

We have tried to set forth here the complementary principle to the one where Government expenditures have created water power the parties util such power should pay for it, namely, that where private interests esta structures on navigable streams which incidentally provide needed navig facilities, the Government should contribute to the cost of such struct To a clear appreciation of the justice of this principle it should be born mind that the Government itself occupies a navigable river only to the ex necessary to protect, preserve, and improve free navigation, and has no herent rights on the stream which it can deed to anyone; that the right power, for instance, made available by the existence of natural falls or rap appurtenant to riparian ownership, and the right to use it is governed by S laws on the subject of private property. Where a river by the expenditur skill and labor may be made useful to mankind for navigation and for powe would not be in the public welfare that the one interest should nullify other, or that the cost of improvements which contribute to both uses of stream should be borne entirely by either interest.

Where a power company avails itself of advantages offered by exis structures erected for navigation purposes and in consequence recompense Government, no one would look upon it as an instance of Government aid, where the Government is asked to contribute toward the cost of a project wh will aid navigation, we have essentially the same relationship between pu and private interests. The development of great wasted water power, in use of which there can be no loss or depletion of the original store, is prop classed with navigation as a great public benefit. There is no inherent re why private enterprise, the only agency acceptable under our political te for accomplishing a public benefit in the one respect, should not be a par of the Government, the only proper agency for accomplishing the other bu greater benefit. Under paternal governments, notably in Germany, w power developments as well as navigation improvements are works of government.

The proposal which the Muscle Shoals Hydro-Electric Power Compan making to the United States Government is essentially an effort to accom in this country, by means in sympathy with our democratic principles, an ob which, measured by its dignity and importance alone, is worthy to be ploited and accomplished by the Government. To look upon such a pro as a request for Government aid to a private enterprise would be to pro from a narrow and provincial basis, or to close one's eyes to the import and dignity of the end which it is sought to accomplish.

Respectfully submitted.

FRANK S. WASHBURN,
President Muscle Shoals Hydro-Electric Power C

APPENDIX No. 17.

DESCRIPTION OF THE ENGINEERING PLANS SUBMITTED BY MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY.

By FRANK S. WASHBURN,
President and Consulting Engineer.

CHATTANOOGA, TENN., *May 7, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under an amendment to the rivers and harbors bill, second session, Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals, on the Tennessee River, State of Alabama.

GENTLEMEN:—A special set of fourteen plans was sent to each member of your Board. For the purpose of identification they may be referred to as belonging to Series N, Nos. 1, 2, 4, 6, 12, 13, 14, 15, 16, 17, 18, 20, 21, and 22. They show the general features of this company's project and confine themselves to the portrayal of such things as are determining factors in indicating the merits of the enterprise and its limitations.

DESCRIPTION OF MUSCLE SHOALS.

The Muscle shoals on the Tennessee River, in Lawrence, Colbert, Lauderdale, and Limestone counties, State of Alabama, are at the point where the stream passes from the refractory resistent Paleozoic formations to the softer and more easily eroded Cretaceous. They extend from the foot of Little Muscle shoals, at the town of Florence, to the head of Elk River shoals, near Lock A of the United States Canal, a distance of 30 miles. In this distance the river at low water has a fall of 130 feet. For more than half this distance, lying chiefly from a point opposite Lock 1 of the United States Canal to a point opposite Lock 9, the river at ordinary stages is a series of tumbling, swift-running rapids, averaging from 3 to 5 feet in depth and 1½ miles in width. Here the refractory siliceous limestone which composes the bottom of the river has resisted erosion so strongly that the stream has cut back the more easily eroded banks and made for itself a broad, deep trough whose sides are vertical massive ledges. Wherever for any reason hard ledge rock is missing in the cross section of the stream there has been worn a deep, narrow channel, as in the case of the Bainbridge Ferry section lying between Little Muscle shoals and Big Muscle shoals, where in a distance of about a mile the stream narrows from a width of three-quarters of a mile to one-fifth of a mile, and widens again to three-quarters of a mile, and deepens from 5 feet to 60 feet, and shallows again to 5 feet.

In the length of the shoals there are two distinct rock formations, the contact showing in the stream bed between Locks 5 and 6 and on the north bluff at a point between Locks 6 and 7. Both formations are massive limestone lying in almost horizontal beds, the lower one being an excessively refractory siliceous rock with the characteristic conchoidal fracture of flint, and forming the foundations at the sites of proposed Dams Nos. 1 and 2. The superimposed rock is somewhat less hard, but is massive and bears every evidence of being strongly resistant to water wear and weather.

DESCRIPTION MUSCLE SHOALS CANAL.

The current in [illegible] each year is [illegible] other craft. [illegible] was complete[illegible] shoals by [illegible]

[illegible] too swift and the depth [illegible] them to be traversed by [illegible] when the present [illegible] tricted, has been [illegible] lowing the bluffs of the [illegible] abankments. This [illegible] feet. The upper [illegible] has been made [illegible] ills and has [illegible] length. The [illegible] width of the surface of the [illegible] feet depth for navigation [illegible] at Lock 2 in the [illegible] 2 feet, and 14 [illegible] miles average slope [illegible] miles. The new channel [illegible]

the entrance to Elk River division shows at extreme low water a depth of 1 foot, the 8-mile stretch between the two divisions shows 16 inches, the Pattons Island channel at the lower end of the Little Muscle shoals, a stretch of 6 miles, shows 16 inches at the head of the island, and somewhat in excess of this at various other points in the channel.

The cost of the canal was approximately $3,500,000, and there has been expended in the sixteen years of its existence for maintenance and operation about $1,000,000 additional.

PURPOSES OF THE MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY.

The purpose of the Muscle Shoals Hydro-Electric Power Company is to place across the river three dams 40 to 50 feet in height, with a large boat lock in each, forming three pools covering the entire length of the Muscle shoals, thus providing any depth for navigation that may be desired. The present plans are based upon 6 feet minimum depth over the miter sills of the locks. At each of these dams it is proposed to place a power house with generating machinery for the purpose of developing electric power.

POWER POSSIBILITIES.

It is safe to count upon an average working head of 120 feet at all the dams, divided about equally among the three. On the basis of an average working efficiency of 80 per cent in the turbines, 94 per cent in the generators, 97½ per cent in the step-up transformers, 90 per cent in the transmission lines, and 97½ per cent in the step-down transformers, 60 per cent of the potential power of the water passing to the turbines may be delivered as useful available power. Consequently each thousand second-feet working under 120-foot head may be transformed into 8,200 useful horsepower. Ultimately the great expanse of the third pool may provide storage sufficient to tide over to an appreciable degree the extreme low flow in the Tennessee River which comes during the late fall and early winter of each year. Until that time, however, it is evident, apart from an uncertain and indifferent amount of regulation which can be effected in pools 1 and 2, that the amount of power which can be delivered at any moment will be determined by the coincident flow of the stream.

The Tennessee River is subject to extraordinary variations in flow. It is believed to have dropped to as low as 10,000 second-feet at its mouth and risen to 700,000 second-feet. There are no consecutive discharge gaugings of the river except at Chattanooga, 207 miles above the foot of Muscle shoals. They were made by the United States Geological Survey under the direction of the United States Engineers and cover the time from January, 1890, to date. The ten years 1896 to 1905, inclusive, are of special interest, as they seem to afford a long consistent low-flow period. Drawing N–1 is a stream-flow diagram giving the monthly mean and minimum flow of the Tennessee River at Chattanooga for the years 1890 to 1905, compiled from these measurements. The years 1896 to 1901, inclusive, show a minimum monthly mean flow of approximately 8,000 second-feet occurring in 1897 and 1899, a minimum flow of 4,300 second-feet occurring in the year 1897, and 6,600 second-feet in 1899. From 1902 to 1905, inclusive, the minimum monthly mean flow was 5,500 second-feet in 1904 and 7,050 second-feet in 1903. The minimum flow which occurred in the year 1904 was 5,000 second-feet.

Drawing N–2 is a mass diagram prepared primarily for the purpose of showing the amounts of storage required to insure any given draft on the river at Chattanooga, based on the gaugings 1890 to 1905. The table at the right-hand end summarizes the results. The diagram shows also the number of days in each low-flow period, 1890 to 1905, that the stream delivery was below any given amount. These results are summarized in a subsidiary diagram attached hereto plotted to ordinates of time and flow. This diagram indicates that the Tennessee River at Chattanooga flowed less than 7,500 to 8,000 second-feet from 10 per cent to 15 per cent of the time in the worst year of drought of record and 5 per cent of the time as applied to the entire period of ten years.

It is safe to assume that the long, broad, comparatively flat stretch of the river between the lower end of the mountain section just below Chattanooga and the head of Muscle shoals acts automatically as a regulator of the flow, reducing the flood peaks at the shoals as compared with those at Chattanooga, and raising the minimum flow materially. The area of the watershed above

Chattanooga is about 22,000 square miles and above Muscle shoals about 29,000 square miles. The greater area of the latter place compared to the former would naturally tend to increase the minimum flow. It is only from a contemplation of these comparisons that any light can be thrown upon the relation between the amount and characteristics of the discharge at Muscle shoals and at Chattanooga.

The amount of horsepower which it is practicable to assume as commercially obtainable from any stream without storage facilities should be taken as greater than the equivalent of the absolute minimum flow of the stream through a long series of years. The available horsepower under the physical and commercial conditions before us is in part a function of the low monthly mean flow of an average year of drought, particularly as in the present instance the difference is small between the monthly mean and minimum flow when the river is low. It is impossible to fix the basis exactly by any exact method of approach. It must be determined, in the absence of a long continuous series of stream gaugings at the exact point where power is to be developed, by applying the judgment to more or less disconnected facts, and the result of experience upon similar streams to the one under consideration. In the present case it is believed that 12,000 second-feet is the flow at Muscle shoals, which represents the measure of commercially available power. This under 120 feet head will give approximately 100,000 horsepower. It is proposed to install ultimately at the lower dam 50,000 kilowatts of generating machinery, as shown by Drawing N–22. However, this is not a measure of the annual horsepower which it is practicable for the Tennessee River to deliver at this structure unaided by storage.

LOWER DAM.

Dam No. 1, the lowest on the stream, is somewhat over 2 miles above the Florence Railroad bridge and 205 miles by river below Chattanooga; it spans the river at the head of Pattons Island, where, at the height of the masonry lip of the dam, there is a distance of 4,110 feet between the rock buffs on either side. The elevation of masonry lip Dam No. 1 is 452.5 feet. The adjustabe crest of the dam will raise this height 5 feet, namely, to elevation 457.5 feet. This is 40 feet above the proposed elevation of water in the boat channel below the lock in Dam No. 1, namely, 417.5. The boat channel as at present will be between Pattons Island and north bank of river, but the present level will be raised about 10 feet measured at the site of Dam No. 1. To maintain this higher level it is proposed to place a dam across the narrow channel at the foot of Pattons Island in accordance with the plan which we understand has already been favorably reported upon by the Engineering Corps, United States Army. The drawings N–20, N–14, N–16, and N–13 show these matters in detail. It will be seen from drawing N–21 that the length of Pattons Island channel will be approximately 14,000 feet, and for 12,000 feet the island is above the elevation to which the surface of the water is to be raised in the channel, and at no point in the remaining 2,000 feet is the crest of the island more than 3½ feet below that elevation. Dam No. 1 forms a pool which will cover the shoals to a minimum depth of 6 feet at every point between Dam No. 1 and the lock in Dam No. 2. This pool drowns out Locks Nos. 9, 8, and 7, Muscle Shoals Canal, and its extreme low level, namely, at the height of the masonry lip of Dam No. 1, is at the same elevation as the surface of the water in the present Muscle Shoals Canal below Lock No. 6. Thus, until such time as Dam No. 2 is built, the Muscle Shoals Canal will be operated down as far as Lock No. 6. Locks Nos. 9, 8, and 7 and the Shoal Creek aqueduct will be submerged and abandoned. Six-foot navigation will be provided at all times from the Florence Railroad bridge through Pattons Island channel over the Little Muscle shoals, where the minimum depth is now about 16 inches, up to Lock No. 6.

MIDDLE DAM.

Dam No. 2 is to cross the river between Locks Nos. 6 and 5 of the Muscle Shoals Canal 8 miles above Dam No. 1. The width of the stream between rock buffs at the elevation of the masonry lip is 6,533 feet. The elevation of the masonry lip of Dam No. 2, namely, 492.5, is 40 feet above the masonry lip of Dam No. 1. The surface of the pool formed by Dam No. 2 will be everywhere not less than 6 feet above the bottom, up to the site of Dam No. 3. The pool, by the addition of a 5-foot movable crest raising the surface elevation to 497.5,

will submerge Locks Nos. 5, 4, and 3. By deepening the canal for a short distance below Lock No. 2, and possibly by altering Lock No. 2 slightly, the whole of the Muscle Shoals Canal below Lock No. 2 may be abandoned after Dam No. 2 has been constructed. Drawings N–17, N–4, N–14, and N–20 show clearly the conditions just described.

UPPER DAM.

Dam No. 3 is to span the river just below Lock No. 2 of the Muscle Shoals Canal, and approximately 8 miles above Dam No. 2. Here the stream between the rock walls at the elevation of the masonry lip of the dam is 6,125 feet wide. The elevation of the masonry lip is 40 feet above the masonry lip of Dam No. 2, placing the extreme low level of the pool above Dam No. 3 at elevation 532.5. This is 2 feet above the low water at Decatur, 27 miles above Dam No. 3. The addition of a movable crest on Dam No. 3 will enable this surface to be raised 5 feet at least. The extreme low-water level of the pool submerges both locks of the Elk River division of the Muscle Shoals Canal and provides not less than 6 feet navigation to Decatur.

Thus it will be seen that the plan for the three dams provides any desired depth of navigation within reasonable limits from the Florence Railway bridge to and above Decatur, covering the entire Muscle shoals and the shallow bars within their limits and above and below, a distance of over 45 miles. Drawings N–18, N–15, and N–14 show these conditions in detail.

By reference to drawings N–13, N–4, and N–15, showing the river soundings at the sites of Dams Nos. 1, 2, and 3, respectively, it will be seen that the depths over the foundations at low water, except in a few possible isolated holes, are not to exceed 3 feet at Dam No. 1, 5 feet at Dam No. 2, and 4 feet at Dam No. 3. An examination of the river at these points will show that the bottom of the river is clean, hard, close-textured, siliceous limestone, "chert," containing probably over 80 per cent silica. There is no gravel or other material on the bottom. At side of Dams Nos. 1 and 2, there are islands in the river formed by silt deposited upon the old rock bottom of the river.

LOCKS.

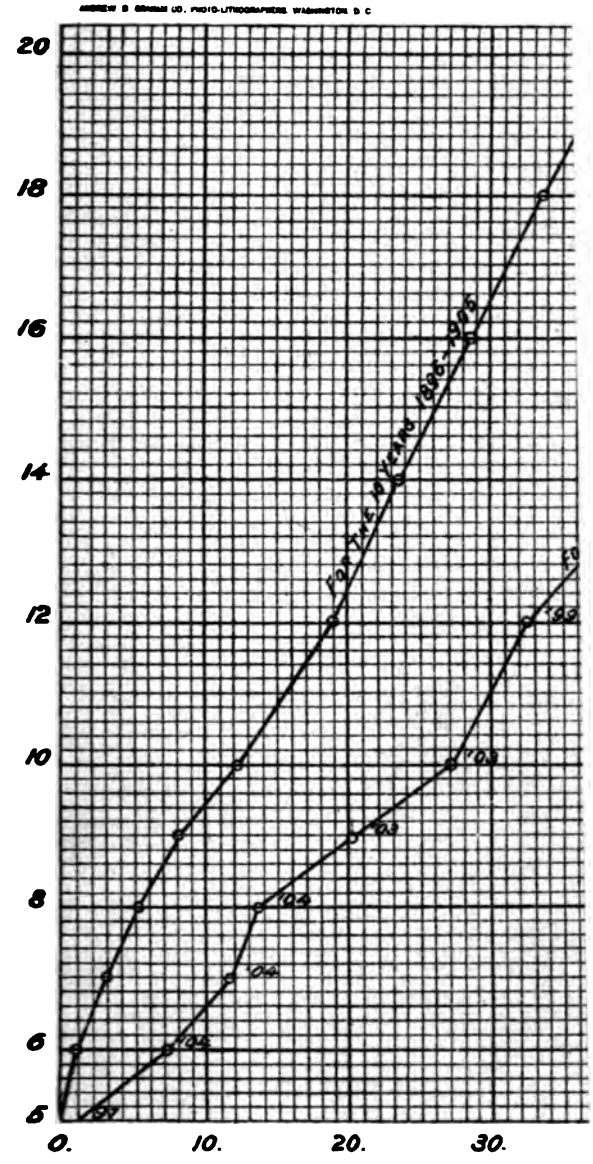
Drawings N–6 and N–12 show the locks proposed for Dams Nos. 1 and 2, and are copied from designs of Hales bar lock, now under construction at the "Suck" below Chattanooga. The dimensions of these structures are such as to bring the unit of stress upon the masonry, the position of the resultant and factor of safety against overturning within the limits prescribed by the Engineering Corps of the United States Army for such structures. The purpose in the lock plans was to follow what has already been approved by the War Department.

ESTIMATES OF COST.

The detailed estimates of quantities and cost submitted herewith are for, first, the locks, including the labor of setting the gates and their anchorages, but excluding gates and appurtenances, power plant, pumps, lock tenders, houses, etc.; second, the dams complete, including 5-foot movable crests; third, the substructures of power houses, excluding gates, penstocks, and appurtenances. The cost of generating machinery, switchboards and appliances, protective apparatus, transformers and transmission lines, power-house superstructure, and buildings of all kinds is not included in the detailed estimate because in the matter of lock machinery and appurtenances the type and design, and consequently the cost, would be determined entirely by the Corps of Engineers, United States Army, and as regards the detailed estimates of the generating and transmission machinery the Government is not interested directly, as the particular design has no bearing and the cost is to be borne entirely by the company.

The total cost of the power-house superstructure and other buildings on the basis of 100,000 kilowatts generating equipment taken from the company's detailed estimates will be $360,000; generating and transforming equipment, $3,200,000; transmission lines and right of way, $2,100,000; substation land and buildings, $140,000; substation equipment, $700,000. These sums added to the $10,720,000, estimated cost of locks, dams, and power-house substructure, give $17,220,000.

If there were added to this the cost of the land required on the Tennessee River and the gates, machinery, and other appurtenances of the locks, the sum would represent the total investment involved in carrying out the plans presented for your consideration.



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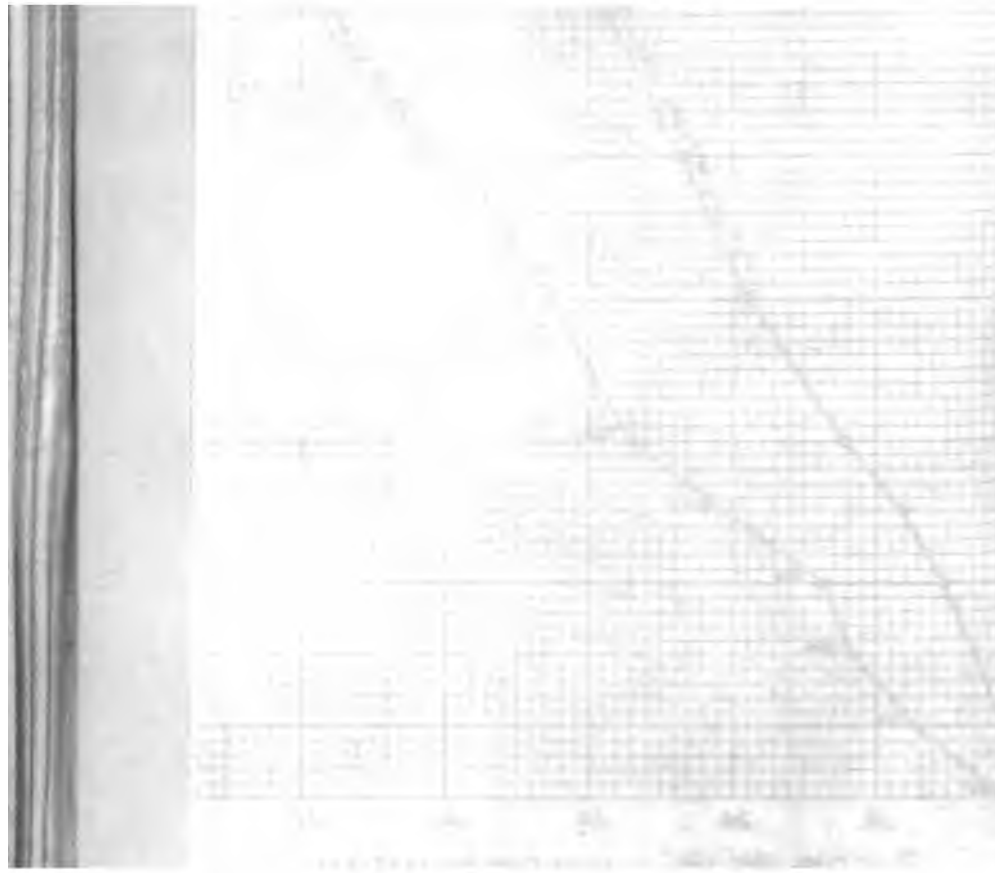


SUMMARY.

The plans here presented are not plans of three independent navigation and power plants. The three units are necessary parts of one whole, particularly in view of the vital effect of regulation of flow at any dam upon the development of power at the one or more dams below and upon navigation.

It is not proposed to hold back at any time any portion of the minimum flow of the river requisite for navigation purposes. Such regulation as may be possible will inevitably be of advantage to navigation, but in the interests of both power development as well as navigation the regulation and use of water at all the dams must of absolute necessity be in the hands of a single corporation.

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY,
By FRANK S. WASHBURN,
President and Consulting Engineer.

MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY.

Estimated quantities and costs of three dams with locks and power-house substructures, May 7, 1907.

[Submitted with the paper immediately preceding.]

Item.	Unit of quantity.	Unit price.	No. 1.		No. 2.		No. 3.	
			Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.
Work (excluding gates and machinery):								
Excavation—								
Rock	Cubic yards	$1.50	25,000	$38,000	25,000	$38,000	30,000	$45,000
Earth	do	.40	2,500	1,000	2,500	1,000	2,500	1,000
Cofferdam	Feet	27.00	1,100	30,000	1,100	30,000	1,100	30,000
Concrete—								
Cyclopean	Cubic yards	6.75	60,000	405,000	60,000	405,000	60,000	405,000
Foundation	do	8.25	4,000	33,000	4,000	33,000	4,000	33,000
Structural	do	9.00	6,000	54,000	6,000	54,000	6,000	54,000
Placing gates, anchorages, etc.	Tons	15.00	600	9,000	600	9,000	600	9,000
Regrading				5,000		5,000		5,000
Total				575,000		575,000		582,000
Dam complete:								
Excavation—								
Rock	Cubic yards	1.50	34,000	51,000	53,000	80,000	48,000	72,000
Earth	do	.40	40,000	16,000	69,000	28,000	3,000	1,000
Cofferdam	Feet	27.00	4,000	108,000	7,000	189,000	11,000	297,000
Concrete—								
Cyclopean	Cubic yards	6.75	180,000	1,215,000	270,000	1,823,000	238,000	1,606,000
Foundation	do	8.25	25,000	206,000	50,000	412,000	47,000	388,000
Crest	Feet	50.00	3,300	165,000	5,900	295,000	5,250	262,000
Total				1,761,000		2,827,000		2,626,000
Power-house substructure:								
Excavation—								
Rock	Cubic yards	1.50	13,000	20,000	12,000	18,000	13,000	20,000
Earth	do	.40	3,000	1,000	2,000	1,000	3,000	1,000
Tailrace, excavating rock	do	1.50	50,000	75,000	48,000	72,000	50,000	75,000
Cofferdam	Feet	27.00	1,700	46,000	1,700	46,000	1,700	46,000
Concrete—								
Cyclopean	Cubic yards	6.75	15,000	101,000	15,000	101,000	15,000	101,000
Foundation	do	8.25	5,000	41,000	5,000	41,000	5,000	41,000
Structural	do	9.00	30,000	270,000	28,000	252,000	29,000	261,000
Slope paving	do	3.00	2,000	6,000	2,000	6,000	2,000	6,000
Structural steel	Tons	70.00	400	36,000	400	36,000	400	36,000
Regrading				6,000		6,000		6,000
Total				602,000		579,000		593,000
Grand total				2,938,000		3,981,000		3,801,000

Total estimated cost, $10,720,000.

It is in effect a railroad itself, with an infinite number of tracks and sidings, with no fixed charges nor interest to pay, with a free and perpetual easement upon its surface to the rolling stock of all alike and free of cost.

The history of traffic shows that at somewhat regularly recurring intervals a state of great congestion exists, and we are now face to face with one of these crises in the history of American transportation facilities. So vital a question has it become that it has now made the subject of special articles running through different magazines, and is also made the subject of debate before the leading industrial and commercial organizations of the country. In this extremity the people have turned to the rivers. A great organization has been formed, national in its scope—the National Rivers and Harbors Congress—for the purpose of moving Congress to adequately support the improvement of our rivers. President Roosevelt has stepped forward in recognition of the great importance of the subject and the prevailing public demand, and upon his own initiative has appointed a nonpartisan commission for the purpose of examining into the conditions of the country as they pertain to the internal natural ways and recommending to Congress a comprehensive plan for their improvement and control by the Federal Government. This Commission will view the situation in its entirety and in its broadest scope, and, therefore, will not be local in function or give specific recommendations pertaining to specific improvements upon specific rivers, all of which individual situations will undoubtedly come before such distinguished boards of Government engineers as your own for particular and individual investigation and recommendations.

It is pertinent to add that the President's Commission is made up of the following gentlemen: Hon. Theodore H. Burton, chairman; Senator Francis G. Newlands, Senator William Warner, Hon. John H. Bankhead, Gen. A. Mackenzie, Dr. W. J. McGee, Mr. F. H. Newell, Mr. Gifford Pinchot, Hon. Herbert Knox Smith. In the appointment of the Commission the President very aptly states: "In creating this Commission, I am influenced by broad considerations of national policy. The control of our navigable waterways lies with the Federal Government and carries with it corresponding responsibilities and obligations." The President also points out in his letter appointing the Commission a number of startling facts of great concern to all the people. He holds that a comprehensive plan should be devised for considering all uses to which any river or stream may be put, and that they be brought together and coordinated in a manner to do fullest justice to all uses. He points out the fact that the railroads are no longer able to move the great crops of the country and the products of the factories; that there are neither railway facilities sufficient nor cars and locomotives in sufficient quantities, nor do the railroads reach all the sections requiring transportation. He points out that although the products of the north interior States, for example, have doubled in ten years, the railway facilities have increased but one-eighth; he holds that there appears to be only one remedy as a cure for this situation, the distressing features of which are rather increasing than abating, and he advises that there is but one complete remedy and that is the development of a complementary system of internal transportation by water.

The Tennessee River stands sixth in importance in point of size among the rivers of the United States, and equals in the discharge of its water the combined discharge of the Ohio and Cumberland. Not only because of its great size, but also because of the vast country tributary to it so prodigally endowed with the best and most valuable resources of nature, and the products of the farm and factory, must it be regarded as one of the most important of the King's highways. This great river bears a broader aspect to the situation as a whole than purely local significance would give to it.

Navigation at any point on the Tennessee River is as important and desirable to the merchant, manufacturer, and shipper in New Orleans as it would be to similar interests in Knoxville, Tenn. But the river fails to serve its function as a commercial highway until the obstructions to navigation which nature has placed there have been removed, and therefore consideration of this artery of commerce must necessarily reduce itself to the consideration of the removal of such barriers at the least cost to the Government.

The President's Commission will doubtless view no river situation more richly endowed with natural advantages than the Tennessee River, and the endowment of this river in so prodigal a fashion will cause the few impediments to navigation to be considered as insignificant blemishes.

Such opportunities as represented by this particular river, if in France, Holland, Belgium, or Germany, although on a much smaller scale, would be seized upon by these several governments and improved at very great cost.

In these countries small canals even have become an indispensable part of their industrial, commercial, and military power. This statement is quoted from Senate Document No. 83, first session, Fifty-ninth Congress. The same document also makes the statement, referring to the Tennessee River: "No other river in the United States has a course along which such vast and inexhaustible resources of industry and commercial wealth are stored." Nature has blessed the Tennessee River in a way in which few other great rivers are favored. Touching upon this thought, it is well to quote from Major Kingman's report to the Chief of Engineers, 1900–1901, as follows: "Owing to the hard bottom and stable banks and ample discharge, the river is particularly favorable for improvement. It never freezes, and therefore escapes one of the principal obstructions to navigation found in most fresh-water rivers."

It is not contended that the present limited traffic upon the Tennessee River warrants the expenditure of the total cost of the Muscle shoals improvements. Its present traffic, however, is not at all a fair measure of the stupendous traffic which will eventually traverse these waters when the river is clear of all obstructions to navigation. The growth of the country is being held back awaiting this corrected situation to eventuate. Does anyone doubt that with the rapidly increasing population of this country, the like of which has no record in past history or in present conditions elsewhere, and the exhaustion of new lands in the far West that the hum of industry will be heard from one end of the Tennessee Valley to the other? Great areas of land which thus far have not been subdued will be put under the plow, and present agricultural districts which have been unable to produce certain crops with a margin of profit will change to new crops which theretofore would have been impossible, on account of the high cost of moving these crops to a market after they have been produced. The change will add many per cent to the values of lands of all descriptions, and the resources to the Government and to the State in taxation will be correspondingly increased, not to mention the wealth which will be added to society by the resulting increase in population, which in itself will give a new impetus to the development of the country's resources.

This picture may not in itself warrant the Government in assuming the many million dollars of great expense which the improvement of navigation would entail, but at this point the local significance of the collateral feature to navigation looms into great prominence. The country for 100 miles or more adjacent to the situation of the three dams proposed by the Muscle Shoals Hydro-Electric Power Company will be beneficiaries as a result of the energy of the river, heretofore wasted for countless centuries, being converted into industrial power and transmitted to their shops and factories for utilization. This incidental advantage the industrial people will get in the same way the commercial communities will be benefited by navigation. The industrial people, through the agency of a quasi public corporation such as the one now before you, will be so much benefited by the realization of a cheaper and better form of power being dispensed to them that they, through the agency of such a company, can well afford to pay a part at least of the cost of the improvements necessary to promote good navigation. These two interests run parallel in their sympathy.

The Government itself has no function by which it can do the thing proposed to be done for the benefit of the industrial people, for its powers extend to navigation alone. This is a right which the State itself can utilize and extend to any of its agencies such as the one before you; so that perhaps it might be considered always fortunate if the Government when confronted by navigation difficulties would find a power possibility as an additional and important feature of the situation, which in itself is sufficiently attractive to investors to take hold of in connection with navigation improvements and to bear their just proportion of the cost thereof.

The disinterested citizen would likely contend that in an improvement of this dual nature where the navigation feature is national in aspect and where the power feature is local, that the division of expense should be in a ratio proportioning the larger share to the Government and the smaller to the power company. This company comes before you in the attitude of an inventor and discoverer of a plan and a possibility, which together with an equipment peculiar to itself offers to establish navigation at much less cost to the Government than the Government can do itself or can have it done by any other agency. This company will be prepared at a later hearing to prove the truth of this and all its contentions. It is true that our plan contemplates the completion of the navigation project in three steps separated not only by several

miles in distance but possibly several years in time as well, and the objection may be offered that the doing of this step by step will give additional navigation in such small increments as to be of little value until the three steps as a whole have been entirely accomplished. We feel, however, that approaching the solution of this great problem in three installments with a definite assurance ahead, is a vast improvement upon what history records of the situation in the past, where much has been said but nothing of practical value been accomplished.

In behalf of the company I wish to thank you for your thoughtful attention to what has been presented to you in my remarks.

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER CO.,
By CHAS. H. BAKER,
Second Vice-President.

APPENDIX No. 19.

HISTORY OF MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY, AND WHAT IT CLAIMS.

By FRANK S. WASHBURN,
President of the company.

CHATTANOOGA, TENN., *May 7, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under an amendment to the rivers and harbors bill, second session, Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals, on the Tennessee River, State of Alabama.

GENTLEMEN: The development of power at Muscle shoals, on the Tennessee River, has been projected by various interests during the past ten years. Many different plans have been formulated with more or less definiteness. They divide themselves naturally into three kinds:

First. A canal taking the water at or below the head of the shoals and carrying it to some point below on a grade less than the slope of the river, and generating power from the fall of the water at the lower end of the canal.

Second. A series of dams across the shoals of such moderate height, not exceeding 12 to 18 feet, and so placed as not to cause submergence of the Muscle Shoals Canal. Power was to be generated by the fall of the water at the dams.

Third. The construction of high dams across the river and the consequent submergence of the Muscle Shoals Canal. Power is to be developed at each of these dams by the fall of water at the dam.

The first plan is impracticable because of the prohibitory cost of the canal. Length sufficient to obtain a practicable working head of water, the broken character of the country along either bank of the river, and the enormous cross section necessary to carry sufficient water to generate a reasonable quantity of power are problems the solution of which is only possible by an expenditure incommensurate with the value of the power which could be produced by this plan.

The second plan involves a series of low dams averaging at least a mile in length, the foundations of which would be extremely expensive as compared with the power which could be developed. The difficulty in maintaining a working difference of level between the head-water and tail-water in times of flood in the Tennessee River would prove so great in the case of low dams as to render their use inexpedient.

The third plan is believed to be the only practicable one from the standpoint of private interests, and the only one which conserves the public interest, for it stands absolutely alone and unique in making available the entire head of the shoals and the entire volume of the river so far as any structural limitations are concerned, and provides navigation over the shoals of the Tennessee River in accordance with modern requirements and future demands.

The Muscle Shoals Hydro-Electric Power Company was incorporated under the laws of the State of Alabama, on the 11th of October, 1906, with an authorized capital stock of $1,000,000, $252,000 of which was paid in.

Early consideration of the situation indicated, in the judgment of the company's agents, that there were certain broad principles for the treatment of Muscle shoals to which any project must subscribe to be ultimately successful.

First. Transformation of the potential power of the river at Muscle shoals is looked upon as a great public benefit. It is an instance of developing natural resources for the use of man comparable to removing ores and coal from the earth, logs from the forest, and fruits from the soil. It has this happy distinction, however, that the supply can not be one whit exhausted in use. For as long as the sun shines so long will the rains fall and the waters flow with undiminished volume. The Tennessee River at Muscle shoals will be able to transform power to the uses of man without sensible diminution long after the coal deposits, the only other known practicable source of power, have been exhausted. Accordingly, in the public interest, the first requisite of any plan for the development of power at Muscle shoals would seem to be that in its ultimate development it shall conserve all the power which nature has so beneficently furnished.

Second. No plan may be viewed as suitable which on the one hand restricts navigation at the present time, or, on the other, makes impracticable the adoption of any navigation improvement which may be demanded in the future.

The most important question in the industrial development of every country is transportation, and in no country does transportation reach the extraordinary importance that it has in the United States. No part of this country is so dependent upon the proper solution of the transportation problem as the Mississippi Valley, and no portion of the Mississippi Valley will profit from improved inland-river navigation to the same extent as the Tennessee River drainage basin.

The rich and extensive undeveloped resources of the region tributary to the Tennessee River, the cheap and bulky character of the products of this region which makes even the minimum cost of railroad transportation practically prohibitory, and the great area to be served, as extensive as that of the whole of England, will demand navigation facilities on the Tennessee River of the most comprehensive and modern type. This means ultimately that lateral canals and attendant numerous locks must be abandoned, particularly at Muscle shoals, where the topographical features are such that marked improvements in the canal can be made only at prohibitory cost if at all. Accordingly, the second requisite of any plan would seem to be that it shall in itself provide for suitable navigation facilities, or at least shall not prohibit the adoption later of the most advanced and capacious means for navigation, namely, the forming of deep slack-water pools.

When the Muscle Shoals Hydro-Electric Power Company came to review the legislation had in Washington bearing upon the development of power at Muscle shoals it promptly discovered that the bill of March 6, 1906, entitled "An act to authorize the construction of dams and power stations on the Tennessee River at Muscle Shoals, Alabama," in effect prohibited the adoption of any plan which subscribed to the two principles just enumerated. The bill provides that the construction therein authorized shall not interfere with the navigation of the Muscle Shoals Canal, and limits the territory in which development of power may be made to a region whose lower limit is considerably above the foot and the upper limit considerably below the head of the shoals.

The plans originally submitted to the War Department by the Muscle Shoals Hydro-Electric Power Company provided for two dams, drowning out the Little Muscle shoals and all the locks of the Muscle Shoals Canal except Nos. 1, 2, and 3. These plans were referred to Maj. H. C. Newcomer, Corps of Engineers, who reported that their general features were considered more favorable to the interests of navigation than any plans hitherto contemplated, but stated that it would be much better to include three dams and locks in the beginning by providing navigation over the entire Muscle shoals and entirely eliminating the Muscle Shoals and Elk River Shoals Canal. Major Newcomer recommended that this change be made if practicable, and accordingly it has been done.

The whole situation was clearly comprehended by the Hon. William Richardson, of Alabama, the author of the original bill, and a subsequent bill was introduced in Congress by Judge Richardson on January 18, 1907, and referred to the Committee on Rivers and Harbors. It is entitled "A bill for the purpose of improving the navigation of the Tennessee River over the Elk River shoals and the Big and Little Muscle shoals, and for other purposes." The first section provides that the Muscle Shoals Hydro-Electric Power Company shall have authority to erect and use perpetually three dams in and across the Tennessee River at Muscle shoals, in the State of Alabama, so designed as to incorporate the necessary conduits, gates, and other appurtenances necessary for the utilization of water power; the first of said dams to be located at the foot of the Little Muscle shoals, the second of the said dams to be located midway of and

across the Big Muscle shoals, and the third of the said dams to be located across the Big Muscle shoals at or near Lock No. 2 of the United States Canal, in such positions relative to each other and of such heights, respectively, as shall develop slack water covering the entire fall in the Tennessee River at ordinary low water from the beginning of the Elk River Rapids to the end of the Little Muscle Shoals Rapids, and to construct a lock in connection with each of the said dams as a part of itself. The company is authorized to operate a power station in connection with each of the dams, such construction to be subject always to such conditions and stipulations as may be imposed by the Chief of Engineers for the protection of navigation, and the property and other interests of the United States. It is provided further that the company in the operation of its power plants shall not disturb the levels of the slack-water pools created by the erection of said dams above or below limits to be prescribed by the Chief of Engineers. The company is to grant to the United States free of cost the use of water for water power for operating the locks, and it is provided that the company shall be liable for any damage that may be inflicted upon private property, and the company shall make no claim against the United States for failure of water power.

The second section provides that detailed plans and specifications for the work in view shall be submitted to the Chief of Engineers, and no departure shall be made from the plans without first obtaining the approval of the Chief of Engineers, it being understood that the dams authorized by this bill will make practicable the entire abandonment of the present Muscle shoals canals along the Big and Little Muscle shoals and the Elk River shoals.

The third section provides that in consideration of receiving title to the locks and land necessary in connection therewith, and of the benefits to be derived by the United States from the improvement of navigation, the United States is to pay for the said locks and appurtenances thereof, together with one-half the cost of the first of the dams to be erected.

The fourth section provides that all the rights acquired under this act shall cease if the company shall fail at any time to comply with any of the provisions of the act or any of the stipulations which may be prescribed by the Chief of Engineers for the conduct of the construction operations, or in case the company shall fail to begin the erection of the first dam within three years after being so authorized by the terms of the act, and shall fail to complete the same within three years thereafter; and shall fail to begin the erection of the second dam before the spill water over the first dam at ordinary low water shall be diminished by utilization for power purposes to the equivalent of five thousand horsepower, and shall fail to complete the same within three years thereafter; and shall fail to begin the erection of the third dam before the spill water over the second dam at ordinary low water shall be diminished by utilization for power purposes to the equivalent of five thousand horsepower, and shall fail to complete the same within three years thereafter. It also provides that the failure to exercise this authority for the construction of the second or third dams, or both of them, shall not operate to terminate the rights pertaining to the first dam. It provides also that the Secretary of War, upon the recommendation of the Chief of Engineers, may extend the time of completion of either of the dams upon the proper showing of good faith by the said company that it has been subject to unavoidable delays.

The fifth section provides that the act shall not be construed as modifying any of the existing provisions of law in reference to protection of navigation and repeals all acts heretofore in effect in reference to the movement of navigation over Muscle shoals.

This bill was viewed with favor by the Committee on Rivers and Harbors, and was referred by the Hon. Theodore E. Burton, chairman, to the Chief of Engineers.

General Mackenzie, under date of February 12, 1907, made a report to Chairman Burton in which he raised various questions and made a number of suggestions, the last one being that any proposition involving injury to or destruction of the Muscle Shoals Canal was a matter of so much importance that it should receive at the hands of the War Department a more prolonged consideration than it was possible to give the matter without delaying a report beyond the close of the Congressional session, and suggested that sufficient time be allowed the Department to investigate and consider the plan through a Board of Engineers. Accordingly, an amendment was then provided to the

rivers and harbors bill authorizing the Secretary of War to appoint a Board of Engineers whose duties should be—

First. To examine the present condition of the United States Canal and the Tennessee River from the head of Elk River shoals to the Florence Railway bridge, with a view to permitting the improvement of this stretch of river by private or corporate agency, in conjunction with the development of water power by means of not more than three locks and dams.

Second. To examine any plans presented by such agency, private or corporate.

Third. To report whether structures built upon these plans can, without injury to navigation, or with advantage thereto, be used to develop water power.

Fourth. To determine what portion, if any, of the expense of the work should be borne by the United States.

Fifth. To report its findings not later than the first Monday in December, 1907.

The amendment further provides that until this Board shall make its report and action shall be taken thereon by Congress no permits shall be issued under the provisions of the act approved March 6, 1906.

Representatives of the Muscle Shoals Hydro-Electric Power Company are this day before the honorable Board appointed in accordance with the legislation referred to in compliance with an invitation extended that company to appear before the Board at its first meeting.

A special set of plans was sent to each member of the Board by invitation. They show the general features of the project, confining themselves to the portrayal of such things as are determining factors in indicating the merits of the project and its limitations.

The importance of the subjects referred to your Board demands more than merely passing judgment upon the technical merits of engineering plans. It is no exaggeration to say that the engineering features, except in their broader aspects, are relatively unimportant. If the engineering project here presented for your consideration in its broad outlines conserves to the highest possible usefulness the navigation possibilities over Muscle shoals and the potential power of the river, then the extent to which the United States Government will cooperate with the Muscle Shoals Hydro-Electric Power Company will, we believe, determine whether these benefits will be secured to the people of this county.

We recognize further that there are involved as factors of more or less weight questions of time, precedence, safeguards, guaranties, costs, and other questions. To present to you at this time much more than a mere statement of where these ramifications may probably carry the investigation is believed to be impracticable. It is natural that the members of the Board should first want a physical core about which to crystallize their ideas, and the order in which the duties of the Board are mentioned in the bill constituting it seems to have had this in view, namely:

First. Examination of the ground;

Second. Examination of the plans;

Third. To determine the effect of the plans upon navigation and the development of power; and

Finally. To determine what portion, if any, of the expense of the work should be borne by the United States.

Accordingly, we present you now this short history of the enterprise which is responsible for the presence here to-day of your Board and ourselves, and spread before you our engineering plans, with suitable written descriptions. We will defer laying before you the specific facts as we see them bearing upon the final question referred to you until you have had the opportunity of visiting and examining the Muscle shoals. We beg your indulgence this day in one additional thing—namely, consideration on your part of what we believe to be the really national importance of the subject before you and the proper sphere of Government in such matters.

Before closing, in order that you may know specifically what we desire to bring before you later, and, if I may be permitted to lapse into a usual form of legal procedure in presenting a case to a judicial body, I will state what the Muscle Shoals Hydro-Electric Power Company expects to prove:

First. That the most meritorious and only practicable plan for securing adequate transportation on the Tennessee River is to abandon the Muscle Shoals Canal and provide slack-water navigation over the whole of Muscle shoals from the foot of the Little Muscle shoals to the head of Elk River shoals.

Second. That if the entire cost of navigation improvements by slack water must be borne by the United States Government the accomplishment of the task will be delayed many years.

Third. That the amount of power practicable of development at Muscle shoals has been greatly overestimated and that if the entire cost of the necessary structures for power and navigation were to be borne by the power enterprise it would be wholly impracticable commercially, and would remain so for an indefinite period.

Fourth. That the cooperation of the United States Government in this matter, to the extent of bearing the cost of the locks and one-half the cost of the dams can not be fairly viewed as a case of Government aid to private enterprise, but rather as a subscription by a private corporation to work which must otherwise ultimately and properly be borne entirely by the Government.

Fifth. That the cost of developing the unit of power has been greatly underestimated, and the rate at which power can be sold when developed has been greatly overestimated.

Sixth. That it is wholly impracticable from the investor's standpoint and undesirable in the interests of the public that the power at Muscle shoals should be developed by a number of private interests instead of by a single corporation.

Seventh. That the proper relation of the United States Government to the proposed Muscle shoals development has no counterpart elsewhere, and can not be compared properly with any combined power and navigation enterprise which has been projected up to this time.

Eighth. That the United States Government has already committed itself by definite legislation to a policy which aids power enterprises upon navigable streams to a much greater extent than is asked in the present instance, and that cooperation in the case under consideration is a natural corollary to what has been declared by Congress to be the proper relationship between the Government and private enterprises where navigation works have already been constructed.

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER CO.
FRANK S. WASHBURN, *President.*

APPENDIX No. 20.

LEGAL FOUNDATION UPON WHICH RESTS THE WATER-POWER PROJECT OF THE MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY AT ELK RIVER SHOALS AND MUSCLE SHOALS, TENNESSEE RIVER, STATE OF ALABAMA.

BY THE GENERAL COUNSEL OF THE COMPANY.

NEW YORK, *October 22, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under an amendment to the rivers and harbors bill, second session Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals, on the Tennessee River, State of Alabama.

FEDERAL AND STATE CONTROL OF RIVERS.

GENTLEMEN: In the beginning of our country's history the people organized themselves into thirteen separate colonies, or States, each State being a sovereign in itself, and clothed with all the attributes of sovereignty. Each State constituted itself into a government which derived its powers and authority directly from the people of the State, and the State government was administered by agents of the people chosen from among them. Later a federation of all the thirteen States occurred, and a central government was organized, called the United States of America, which possesses only such powers and authority as were expressly conferred upon it by the several States as set forth in the instrument known as the Constitution of the United States.

When in the growth of the Union of States, other States applied for and became members of the Union, they became parties to the scheme of Government thus centralized in the United States of America. Under this scheme the United States as a nation became the sovereign, supreme only and to the extent set forth in the Constitution, and only to the extent given and relinquished to it by the several States. Any rights, powers, and authorities which

the States did not relinquish to the central Government specifically as set forth in the Constitution, they held and do now hold unto themselves absolutely, and each State, therefore, is a sovereign, supreme over its own domain and its own people to the extent that it has reserved for itself its rights, powers, and authority, and has not relinquished the same to the central Government.

As respects the respective authority of the Federal Government and the government of the individual States regarding the navigable streams, the line of demarcation is definite and clear. The navigable rivers of the country have from the commencement of our history been regarded as the public highways of all the people, for the purpose of promoting the convenient commerce of the people from point to point or from State to State. The wisdom of our fathers, therefore, is apparent when they caused the several States to vest in the Federal Government the regulation of internal commerce over the navigable rivers of the country.

The power to regulate commerce and navigation was therefore expressly conferred upon Congress by the States in the Constitution of the United States, and such power as therein expressed is simply "to regulate commerce with foreign nations and among the several States, and with the Indian tribes." (Article I, paragraph 8, clause 3.) All other properties and functions of navigable rivers and all properties of unnavigable rivers, such as water power, irrigation, water supply for domestic use, etc., have been withheld by the several States unto themselves perpetually, each of the States assuming to manage for itself in any manner it sees fit as the sovereign of all its people, all properties and functions of rivers, excepting navigation alone, which has been delegated as aforesaid. The Supreme Court of the United States has repeatedly adjudicated and determined the question of the respective interests of the United States and of the States in the navigable rivers of the country, and as touching upon this point I cite the following case:

In Kaukauna Water Power Company *v.* Green Bay and Mississippi Canal Company (142 U. S., 254) the court held that—

"If, in the erection of a public dam for a recognized public purpose (in that instance to improve the navigation on the Fox River, in the State of Wisconsin), there is necessarily produced a surplus of water, which may properly be used for manufacturing purposes, there is no sound reason why the State may not retain to itself the power of controlling or disposing of such water as an incident of its right to make such improvement."

The court further remarked:

"As there is no need of the surplus running to waste, there was nothing objectionable in permitting the State to let out the use of it to private parties, and thus reimburse itself for the expenses of the improvement."

As touching more closely upon the particular subject of the Tennessee River, or that portion of it within the State of Alabama, which, therefore, includes the Muscle shoals and Elk River shoals, I refer to the case of Pollard *v.* Hagan (44 U. S. (3 Howard), 212) in which the court holds that the State of Alabama has the title to the beds of navigable streams within its borders, the same as do the original thirteen States. That decision has been reaffirmed and followed in many later cases by that and other Federal courts until it must be regarded as settled beyond possibility of question. In this connection I refer also to the case of St. Anthony Falls Water Power Co. *v.* Water Commissioners of St. Paul (168 U. S., 360).

The State of Alabama owns the fee to the bed of its navigable streams and the properties of such streams, while the Federal Government has the absolute and unlimited power to control the water of the same for navigation purposes only. This right of the Federal Government, as stated before, flows from the clause in the Constitution, as recited above.

Each State has thus exclusive jurisdiction over the navigation of the waters lying within its territorial limits, and may therefore pass such laws regulating their use as it may deem wise, subject only to the power of Congress, above referred to, to interfere for the regulation of commerce. In this connection I refer to the following cases: Willson *v.* Black Bird Creek Marsh Co. (2 Pet. (U. S.), 245); Lake Shore, etc., R. Co. *v.* Ohio (165 U. S., 365); U. S. *v.* Bellingham Bay Boom Co. (176 U. S., 211); Leovy *v.* U. S. (177 U. S., 621); St. Anthony Falls Water Power Co. *v.* Water Commissioners (168 U. S., 360).

The State of Alabama, when admitted into the Union, became entitled to the soil under navigable waters therein and of the properties of such waters, the same as the original States. (Pollard *v.* Hagan, 44 U. S., 212; St. Anthony Falls W. P. Co. *v.* Water Commissioners, 168 U. S., 360.)

It would therefore seem to be abundantly established by the highest authorities that the only power which the Federal Government has in the matter of navigable rivers is that conferred upon Congress by the States, and such power is limited to regulating commerce—that is to say, to the improvement of the navigability of such rivers, and to the approving or disapproving of contemplated works which may affect navigation.

Now, as to the utilization of the power in a navigable stream toward the cost of any river improvement, or how the State may procure it to be done, whether by its bearing the expenses or a portion of the expenses directly, by charging rentals or tolls or by granting valuable rights and immunities to individuals or corporations, in consideration of such individuals or corporations doing the work at their own expense and without other expense to the State, is a matter with which Congress has no concern, further than to exercise its paramount right to prevent obstruction to navigation It is a matter upon which the States must be permitted to make such bargains as they deem best for their respective interests without interference from any Federal authority.

The necessary conclusion is, therefore, that the State alone, and only the State, can determine the control, operation, management, or disposition of rivers, their waters, water power, or other asset features, or any other feature thereof, save and excepting that of navigation. The State alone is sole proprietor of and has the sole right to dispose of the energy property of its navigable rivers, and of the other asset features which the rivers comprise in their serviceability for irrigation, water power, water supply, etc. The State alone, therefore, can enjoy these property interests in the navigable rivers or dispose of them as it seems most fit to its advantage and to the advantage of its people. The State of Alabama, therefore, reserved all these things to itself, and gave over to the Federal Government only that one feature of its navigable rivers, navigation, over which it made the Federal Government supreme and which was placed first in order of asset value, first in order of usefulness to the people as a whole, not only of the one State, but of other States which are affiliated with it by the bond of commerce.

It is a fact recognized and constantly acted upon that the Federal Government by accepting sovereignty over the navigable rivers of the country has placed itself under a moral obligation to the States to improve the navigation over the same as fast as possible, for the States, having thus relinquished their control are no longer able to control or provide facilities for the internal commerce of their people.

LEGAL FOUNDATION OF THE PROJECT.

There are three prime features which constitute the necessary title upon which must stand a project such as the Muscle Shoals Hydro-Electric Power Company has now under way. These are (1) riparian ownership, (2) Federal consent, (3) State grant.

RIPARIAN OWNERSHIP.

The owner of lands bordering upon an unnavigable stream is by virtue of such ownership the owner likewise of the bed of the stream extending to the thread thereof, together with the property rights of all descriptions which the stream carries. If the stream is a navigable one, the owner of the abutting lands has no ownership in the bed of the river and of the general property elements in the river. These the State holds. He does, however, through the ownership of his land, possess the right of access to and from the river, the use of its water for domestic purposes, and the use of the river in such other ways as do not interfere with the rights of navigation vested in the Federal Government, or of the rights of the State itself in the properties which as sovereign of the people it has always maintained and reserved for itself. The riparian ownership, therefore, of that stretch of a navigable river which may be affected by the improvements necessary for the development of water power is an absolute essential to the consummation of such a project in the hands of the company projecting it. Without the riparian ownership covering that stretch of the Tennessee River along the Elk River and Muscle Shoals Rapids, from the location of its lower dam to the upper end of slack water created by its upper dam, the company's hands would be effectually tied. An adverse riparian owner, under the rights which such ownership gives him, could enjoin through a court of equity any improvement proposed by a water power company which tended in any way to change the river in any degree from its

natural state, to raise it or lower it, to quicken or slacken it, or in any manner to change its quality. Therefore the riparian ownership of the situation in question would stand as a perpetual bar to the inauguration of this great improvement unless that riparian ownership were vested in the company undertaking the improvement, namely, the Muscle Shoals Hydro-Electric Power Company. This company has been most diligent in gathering to itself the lands necessary to insure the full enjoyment of the riparian privileges of the Tennessee River over the stretch covered by the proposed improvement as aforesaid. The company has met with a hearty reception at the hands of the dwellers along the river banks owning the lands in question, and many of these lands have been sold to the company at reasonable prices, and without in any instance prices being made upon an unfair basis or with the display of any purpose of embarrassing the great project.

The state of the titles of the river as a whole along the 30-mile stretch to be improved is about on a par with the ordinary state of rural titles throughout the South, and has not been found to be always satisfactory. Many titles have been found to be mixed and uncertain and the real owners of some landed interests the company has been unable to find. All these deficiencies in title will be cured by the process of condemnation under a law which the State of Alabama passed at its last legislative session for the particular purpose of furthering this improvement.

FEDERAL CONSENT.

In the introductory portion of this paper I have attempted to elucidate the relations of the Federal and State governments to navigable waters. That which was said upon this subject conceded to the United States the sovereign supremacy over navigable rivers as far as the one quality of navigation is concerned. All other interests in a river must step aside and subordinate themselves to the interests of navigation as the feature of prime importance to the people. Therefore any improvement which the State of Alabama may propose with reference to the Tennessee or any other navigable river must be in harmony with the navigation interests of the river as presided over by the Federal Government. Any improvement of any character which the State may propose, or which it may give its consent to, must recognize at the outset the sovereignty of the United States, and conduct such an improvement only with the consent of the Federal Government. Therefore a second and very important feature of the legal title for a foundation to the Muscle shoals project must be the Federal consent. This consent the Federal Government is morally bound to give if the proposed improvement does not interfere in any way with navigation or if it tends to improve navigation. Under such circumstances it is never withheld. Our distinguished countryman, the late Senator Morgan, learned in constitutional laws and the doctrine of State rights, invariably contended that even the formality of obtaining Government sanction was unnecessary where it was evident that navigation is either improved or not interfered with.

The Muscle Shoals Hydro-Electric Power Company has already presented itself before Congress, setting forth a plan and specification of its own for improving the navigation of the Tennessee River over the Muscle shoals and Elk River shoals, and at the same time utilizing in the interests of the public the water power which will result from such an improvement. In this project the Government was asked to participate. The project is so great and so costly in its dual nature that the company finds itself unable to undertake so large a work without soliciting the contemporaneous cooperation of the Government to engage with it jointly in undertaking the double task, which on the one hand will give the Federal Government navigation for its people and on the other hand will give industrial power to the people under the auspices of the State of Alabama. The bill providing for the Federal consent to and participation in this improvement will be before Congress in December next, and your distinguished board by action of the last Congress was created for the purpose of investigating this particular situation and the project designed for it and of advising the next Congress along certain lines to which the law creating your board directed your attention in connection therewith.

STATE GRANT.

Last, and perhaps most important as the essential element or third leg upon which this project must rest for its legal existence, is the grant of the State of

Alabama to the Muscle Shoals Hydro-Electric Power Company of the rights of the State in the several properties of the river which it inherently controls. As set forth in the introduction of this paper, it is clearly plain that the State of Alabama owns in fee the bed of the Tennessee River lying within its borders. It owns absolutely the energy asset within the river. It exercises sovereign control in every way over the river in all features save only the supremely important feature of navigation. Therefore, the Muscle Shoals Hydro-Electric Power Company may not proceed with its project, unless it can stand in the shoes of the State of Alabama itself, as far as that is concerned. Alabama is fully alive to her own interests and the interests of her people, and, as a progressive and liberal spirit prevails in the management of her affairs, she has opened the way for this undertaking as far as she had the power to do so.

The Muscle Shoals Hydro-Electric Power Company went before the State of Alabama at its legislative session last spring and presented its case, asking that the State bestow upon it all its rights of ownership and control in that stretch of the Tennessee River affected by this improvement, asking that it be recognized by the State as a public service corporation, clothed with the power of eminent domain in order to exercise the rights of condemnation for the purposes of this improvement when necessary, and also asking finally that the project be declared exempt from taxations of all descriptions for ten years, in order that the pathway of this great undertaking, beset as it is with so many difficulties, and beginning life as it must with so great a burden, might be made as easy and free from difficulties as it would be possible for the State of Alabama to make it. The State radiated from its every corner with public sentiment favorable to these measures and the legislators, reflecting the minds of their constituents, enacted the necessary laws, which have done much to clear the way ahead for the coming of this improvement.

ALABAMA LEGISLATION.

The laws which I have briefly touched upon have been incorporated in the new 1907 code of the State of Alabama, and in order that their meaning may be entirely clear to your distinguished Board, I have incorporated them in this paper as follows:

"Any person, firm, or corporation, organized for the purpose of improving the navigation upon a navigable river in the State of Alabama, and of developing in connection therewith a water power thereof by a dam and lock, or a system of dams and locks, and electrically transmitting and distributing such power for the use of the public, which shall have acquired the necessary lands on both sides of the said river to the extent at least of one more than half of the necessary abutment sites for the said dam or system of dams, and lock or system of locks, and shall have been organized or incorporated for the specific and particular purpose of improving the navigation of and developing water power in connection with a particular and specified river, and has prepared plans for the construction of a dam or system of dams, and a lock or system of locks appertaining thereto, and filed a copy of said plans in the office of the secretary of state of Alabama, together with a certified copy of its articles of incorporation (if a corporation), which provides both for the improvement of navigation of such river, and for the development of the full water power of the same over the stretch of river thus to be improved, shall have authority to construct a dam or system of dams, with a lock or system of locks appertaining thereto in such river, for the improvement of navigation of the said river by one or more slack-water pools, due to the construction of said dam or dams, and the development of water power in connection therewith, and to that end and in consideration of the benefits to the public by reason of the improvement of navigation of such river and the development of water power thereof as herein provided, is hereby granted an easement for power purposes to and in the waters and bed of the river in which said dam or system of dams, and lock or system of locks, are to be constructed, for the full area covered by the slack-water pools, which will be created by the construction of the said dam or system of dams, to the extent necessary for developing the full power of said river over that length of the same upon which navigation is to be improved as provided herein, and for providing suitable and convenient sites for the said dam or system of dams, locks, power houses, and other features appurtenant thereto and necessary for navigation and power purposes, or for either of them, and to the extent made necessary by the impounding, diversion, and conversion of the said waters as the same may be caused by the construction of the said dam or

system of dams, or by any other change from the normal state of the said river due to said construction and necessary for the purpose of deriving the energy therefrom.

"*Improvement of navigation.*—Any such person, firm, or corporation may exercise the power of eminent domain for the purpose of acquiring such lands as it may be necessary or convenient to flood or otherwise utilize in order to improve navigation as provided in this article, such lands to include as well as all the area submerged, a strip of land 50 feet in width bordering upon the margins of the slack-water pool or pools as the same may be defined at the highest stage of the river at any time after the completion of the improvements herein provided for, and the right hereby conferred to exercise such power of eminent domain is cumulative. No person, firm, or corporation, shall acquire the rights by this act granted, unless the dam or system of dams, and lock or system of locks, to be constructed, will by the operation thereof improve the navigation of the river in which the dam or system of dams, lock or system of locks, are to be built, and will develop the full power of such river over the length of the same upon which navigation is to be improved as provided in this act: *Provided*, That such person, firm, or corporation, shall commence work on said dam or system of dams, and lock or system of locks, within five years from the date of securing the consent of the Federal Government to do so, and shall complete the same within the time prescribed by the United States Government: *Provided further*, That no foreign corporation shall acquire the rights granted in this article until it has complied with the laws of Alabama with reference to foreign corporations.

The person, firm, or corporation which first in point of time, shall have complied with the provisions of this article shall be entitled to all the rights and privileges herein granted; and the operation of this section shall be retroactive."

The terms of the foregoing law have been fully complied with by the Muscle Shoals Hydro-Electric Power Company. The company has, as will be apparent from an inspection of the accompanying map, acquired in fee "at least one more than half of the necessary abutment sites for the said dam, or system of dams, &c.," as shown by the accompanying map. The company was duly organized and incorporated as required by the terms of the law "for the specific and particular purpose of improving the navigation of and development of water power in connection with a particular and specific river, &c." The river specified in the articles of incorporation is the Tennessee River, and the purpose of improving the Elk River shoals and Muscle shoals has been duly set forth in the said articles in the following language, which I quote from the articles of incorporation aforesaid:

"To develop under full head the potential power of the Tennessee River in passing over the Big and Little Muscle shoals and Elk River shoals and to improve navigation over the same, and to secure lands and riparian and water rights necessary therefor, and for this purpose and in connection therewith to erect and use perpetually 3 dams in and across the Tennessee River in the State of Alabama, so designed as to incorporate the necessary conduits, gates, and other appurtenances necessary for the utilization of water power; the first of said dams to be located at the foot of the Little Muscle shoals, the second of the said dams to be located about midway of and across the Big Muscle shoals, and the third of said dams to be located across the Big Muscle shoals at or near lock No. 2 of the United States canal, in such positions relative to each other and of such heights, respectively, as shall develop slack water, covering the entire fall in the Tennessee River at ordinary low water from the beginning of the Elk River Shoals Rapids to the end of the Little Muscle Shoals Rapids, and to construct a lock in connection with each of the said dams as a part of itself; and to erect, maintain, and operate in connection with each of said dams a power station for the development of water power, to be used and sold as such, or for the transformation and transmission of the same, electrically or otherwise, to such places where it may be sold to and used by the public, such construction being subject always to the provisions, requirements, conditions, and stipulations as may be imposed by the Chief of Engineers and the Secretary of War for the protection of navigation and the property and other interests of the United States, and to sell water to the public and to municipal corporations for domestic, sanitary, irrigation, and power purposes."

I now place before your Board a copy of the Articles of Incorporation of the Muscle Shoals Hydro-Electric Power Company.

The law also required that there be "Filed a copy of said plans in the office of the secretary of the state of Alabama, together with a certified copy of its

articles of incorporation, which provide both for the navigation of such river, and for the development of the full water power of the same over the stretch of river thus to be improved, etc." This has been done in a letter of transmittal from the company to the secretary of the state of Alabama under date July 17, 1907, and duly acknowledged by the said secretary of state in a letter dated August 20, 1907, copies of which letters are at your disposal.

The law exempting the company from taxation is as follows:

"To encourage the development of the various unused water powers of this State, the plants, and the property, business and franchises, necessary for the production, transformation, and distribution of electric current, of any person, or firm, or of any corporation, organized for the purpose of developing hydro-electric power for the use of the public; shall, in consideration of the benefits to be derived by the public from the development and operation of such properties and plants be, and the same are hereby, exempt from State, county, and municipal property and privilege taxation of all description, either under general or local laws, until ten years after the beginning of the construction of any such plant. Nothing in this act shall be so construed as to exempt from taxation the lands upon which such plants are erected; nor shall this act be so construed as to exempt from taxation any of the property, business, or franchises of any hydro-electric power plant already developed."

Approved July 27, 1907.

LEGAL POSITION OF MUSCLE SHOALS COMPANY.

In conclusion, a review of the legal foundation of this project discloses the fact that the Muscle Shoals Hydro-Electric Power Company—

1. Possesses all the rights and properties of the State of Alabama appertaining to the Tennessee River and necessary for the proposed improvemets.
2. That this company owns or is in the way to own the necessary riparian rights.
3. That the State of Alabama has indorsed the project as being in the interest of the people by exempting the company from taxation of all descriptions, municipal, county, and State, for ten years.
4. That the company lacks but one item to complete its legal position and enable the project to take form and proceed, and that is the Government consent. As a forerunner to this, Congress has created your distinguished Board for the purpose of advising it at its new session upon the questions which have been referred to you for the purpose of obtaining the benefit of your wisdom and your able counsel in the premises.

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER CO.,
By ——— ———
General Counsel.

APPENDIX No. 21.

FEDERAL PARTICIPATION IN CORPORATE AND PRIVATE PROJECTS WHICH ARE CALCULATED TO ESTABLISH COMMERCE AMONG THE STATES, OR IN FURTHERANCE OF OTHER PROJECTS FOR THE PUBLIC WELFARE, IS A WELL-ESTABLISHED PRINCIPLE OF THE GOVERNMENT, AS SHOWN BY INNUMERABLE PRECEDENTS THROUGHOUT ITS ENTIRE HISTORY.

BY CHAS. H. BAKER,

Vice-president Muscle Shoals Hydro-Electric Power Company.

NEW YORK, *October 30, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under an amendment to the rivers and harbors bill, second session Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals on the Tennessee River, State of Alabama.

Governmental cooperation.

GENTLEMEN: The astonishing progress of the United States during the comparatively brief period of its history has been due principally to the spirit of cooperation and encouragement for individual effort which is woven into the

fabric of the Constitution of the United States. The scheme of government has been projected along lines helpful to the people and calculated for their own welfare and that of their posterity. The principle of lending encouragement has been applied principally to those of progressive temperament, like the hardy pioneer type who went out beyond the borders of civilization and amid terrible trials and hardships blazed the way for the coming of that new civilization which conquered the wilderness and which became the Mecca of wholesome happiness and achievement alike to all. Thus it was that the Government bestowed upon those who had more courage and hardihood than the others free lands for homes and farms in the West, in order that they might pioneer and settle the great public domain under the helpful stimulus which the Government gave them.

While westward the course of empire thus slowly took its way, a handicap settled upon the newer civilization like a ban, because there were no facilities by which the pioneer settlements could establish commerce among themselves or with the eastern sections from which they had emigrated. A civilization thus auspiciously begun was destined to stand still for the lack of the means of travel and communication. Railroads there were in the East among the more settled communities, but in the sparsely settled districts of the West, in those pioneer days, who was there who would venture to build a railroad to draw the new communities nearer to the older civilization? There was no one man nor aggregation of men who alone could do this for the people, and so it became the function of government to participate and make transportation projects possible which otherwise would never have been born. And thus it came about that the progressive spirits of the time projected the Union Pacific Railway across the country as an artery of commerce to further the development of the country and promote the comfort and prosperity of the people.

The Government took a hand in this project, for it meant the scattering of population throughout the West, the development of the natural resources, the absorption and occupation of Government lands by the people, increased revenue due to increase of taxable property, and the enhancement of values wherever the influence of the project would be felt. It was good business, therefore, and in the interests of all the people for the Government of the United States, to indorse this project and to participate in it by the cession to it of a vast allotment of the public domain as a contribution to the enterprise, and to lend it its credit, as well—for the problem was a financial one as well as a physical and engineering one.

FINANCIAL PARTICIPATION.

The United States, therefore, financed 6 of the pioneer railroads of this country which opened the great West to the progress of our civilization. A right of way and certain public lands were granted to the several Pacific Railroad companies by act of Congress, and provision was made requiring the Secretary of the Treasury to issue to the companies upon the completion of sections of their several roads United States bonds at the rate of $16,000 per mile, except for certain parts more difficult of construction, for which they were to be issued at the rate of $32,000 and $48,000 per mile, respectively. These bonds were given to the railroad companies as a loan from the Government, thus placing the Government credit at the disposal of the enterprises where the enterprise of itself and standing alone would have no credit. The bonds ran for thirty years and were retired at their maturity from the surplus earnings of the transportation lines, which during the period of the bonds had developed a profitable business. The railroad companies in which the United States thus participated, together with the amounts in which the Government thus involved itself, are shown by the following table from data furnished by the United States Treasury Department:

Central Pacific Railroad Company of California	$25,885,120
Union Pacific Railroad Company	27,236,512
Kansas Pacific Railway Company	6,303,000
Hannibal & St. Joseph Railway Company	1,600,000
Sioux City & Pacific Railway Company	1,628,320
Western Pacific Railroad Company	1,970,560
Total	64,623,512

Had the Federal Government not taken the stand it did and participated in these transportation projects, which would have been entirely impossible of

accomplishment by private capital alone, the development of the great resources of the West might have been delayed indefinitely. It does not seem so long ago that California was reached from the East only by "prairie schooner" overland, or by sailing around Cape Horn, requiring many weeks in the passage, and the situation would have remained like that for many years thereafter had not the pathfinders of our newer civilization projected the Pacific railroads through the wilderness and across the deserts with the cooperation of the strong arm of the Federal Government to back their progressive spirits.

LAND CONTRIBUTIONS.

But the Government not only lent its credit and prestige to the financial operations, making possible these great arteries of commerce, but it endowed them plenteously as well with vast land grants, the value of which as soon as the roads were completed was sufficient almost in the several cases to pay the cost of the roads, and the values of the same since then have so much increased as to become a most substantial asset of the different railroads. The Government has been indeed generous in dispensing its landed estate in a manner calculated to make possible these transportation agencies. The participation is the same in principle whether the Government gave of its land, or its money, or its credit, and the history of our country shows that it has given all of these at times in the manner which this paper will attempt to set forth.

For the purpose of showing the grand scale of prodigality with which the Government has viewed internal transportation agencies, I incorporate the following table, derived from the General Land Office, showing all the land grants of the United States which have been made as contributions toward the construction of railroads, wagon roads, canals, and river improvements:

FOR RAILROADS.

Date of grant.	Grantee.	Area certified or patented.	Length of road.
		Acres.	*Miles.*
Sept. 20, 1850	Illinois Central R. R. Co	2,595,053	707.73
Do	Mobile and Ohio R. R. Co	419,528.44	
Do	do	737,130.29	498
June 10, 1852	Hannibal and St. Joseph R. R. Co	603,166.34	206
Do	Pacific R. R. Co	1,161,164.51	241
Feb. 9, 1853	Cairo and Fulton R. R. Co	63,294.17	394.5
May 15, 1856	Burlington and Missouri River R. R. Co	888,934.08	279.98
Do	Mississippi and Missouri R. R. Co	607,461.68	317.75
Do	Iowa Central Air Line R. R.	1,082,363.29	274.2
Do	Dubuque and Pacific R. R. Co	1,155,956.54	326.58
May 17, 1856	Florida, Atlantic and Gulf Central R. R. Co	1,304,963.70	370
Do	Florida R. R. Co	290,183.28	237.65
Do	Alabama and Florida R. R. Co. of Florida	165,688	44
Do	Alabama and Florida R. R. Co. of Alabama	394,522.99	119
June 3, 1856	Tennessee and Coosa R. R. Co	67,784.96	36.5
Do	Coosa and Chattanooga R. R. Co		37.5
Do	Northeast and Southwestern R. R. Co	649,676.98	272
Do	Mobile and Girard R. R. Co	504,145.86	223.6
Do	Tennessee and Alabama Central R. R. Co	438,905.99	183
Do	Alabama and Tennessee Rivers R. R. Co	457,215.37	167.35
Do	Bay de Noquet & Marquette R. R. Co	123,000	20
Do	Marquette and Ontonagon Ry. Co		
Do	Ontonagon and State Line R. R. Co		75
Do	Marquette and State Line R. R. Co		
Mar. 3, 1856	Peninsula R. R. Co	517,825.60	125.2
June 3, 1856	Amboy, Lansing and Traverse Bay R. R. Co	743,009.36	261.37
Do	Grand Rapids and Indiana R. R. Co	852,960.12	338
Do	Detroit and Milwaukee R. R. Co	80,998.75	110
Do	Flint and Pere Marquette R. R. Co	512,337.08	170.66
Do	La Crosse and Milwaukee R. R. Co	1,115.38	39
May 5, 1864	Tomah and Lake St. Croix R. R. Co	768,170.05	156.9
Do	St. Croix and Lake Superior R. R. Co	782,691.88	149.5
June 3, 1856	Chicago, St. Paul and Fond du Lac R. R. Co	545,575.76	116
Do	Vicksburg, Shreveport and Texas R. R. Co	359,212.68	190
Do	New Orleans, Opelousee and Great Western R. R. Co	51,452.08	80
Aug. 11, 1856	Southern R. R. Co	198,028.41	113.5
Do	Gulf and Ship Island R. R. Co		170
Mar. 3, 1857	Minnesota and Pacific R. R. Co	1,251,046.14	12
Do		647,038.49	73.56
Mar. 3, 1865		1,258,348.99	317.4
Mar. 3, 1857	Southern Minnesota and Minnesota Valley R. R. Co	1,146,888.52	190
Do	Minneapolis and Cedar Valley R. R. Co	179,706.01	115
Do	Winona and St. Peter R. R. Co	1,676,767.31	323.22
Do	Southern Minnesota R. R. Co	59,619.45	76.5

FOR RAILROADS—Continued.

Date of grant.	Grantee.	Area certified or patented.	Length of road.
		Acres.	*Miles.*
July 1,1862	Union Pacific R. R. Co	2,616,258.08	1,088.66
Do	Leavenworth, Pawnee and Western R. R. Co	164,721.51	106
Do	Central Pacific R. R. Co	447,708.08	123.16
July 2,1864		1,040,219.59	737.5
July 1,1862	Hannibal and St. Joseph R. R. Co. of Missouri	218,250.08	100
Do	Union Pacific R. R. Co	41,288.28	101.77
Mar. 3,1863	Leavenworth, Lawrence and Galveston R. R. Co	69,104.95	142.8
Do	Atchison, Topeka and Santa Fe R. R. Co	2,984,522.68	469.35
Do	Union Pacific R. R. Co., Southern Branch	712,895.19	180.5
May 5,1864	Portage, Winnebago and Superior R. R. Co	785,199.68	241
Do	Lake Superior and Mississippi R. R. Co	838,581	154.42
May 12,1864	Sioux City and St. Paul R. R. Co	281,858.88	83.16
Do	McGregor Western R. R. Co	324,014.07	251
July 2,1864	Burlington and Missouri River R. R. Co	2,573,280.77	199.75
Do	Northern Pacific R. R. Co	1,067,259.21	78.89
July 4,1866	Southern Minnesota R. R. Co	451,245.42	279.57
Do	Hastings, Minn., and Red River	312,770.77	202.1
July 23,1866	St. Joseph and Denver City R. R. Co	462,573.24	226
July 25,1866	California and Oregon R. R. Co	1,202,433.61	304
Do	Oregon Central R. R. Co	322,062.49	260
July 27,1866	Atlantic and Pacific R. R. Co	959,206.87	
Do	Southern Pacific R. R. Co	1,040,430.08	556
May 4,1870	Oregon Central R. R. Co		144.5
Mar. 3,1871	Southern Pacific R. R. Co	187,719.65	348.97
Do	New Orleans, Baton Rouge and Vicksburg R. R	679,287.64	260
Total		44,464,719.18	14,980.66

FOR WAGON ROADS.

Feb. 28,1823	State of Ohio	49,177.45	
Mar. 2,1827	do	21,590.09	
Do	State of Indiana	170,580.24	
Mar. 3,1863	State of Michigan	221,013.35	125
Do	State of Wisconsin	302,980.96	158
June 20,1864	State of Michigan		
July 2,1864	Oregon Central Military Road Co	402,240.67	420
July 4,1865	Corvallis and Yaquina Bay Wagon Road Co	76,385.98	47
July 5,1866	Willamette Valley and Cascade Mountain Wagon Road	548,749.53	448.7
Feb. 25,1867	Dalles Military Road Co	126,910.23	357
Mar. 3,1869	Coos Bay Wagon Road Co	104,000.01	68
Total		2,014,084.51	1,617.7

FOR CANALS.

Mar. 2,1827	State of Indiana	234,246.73	
May 29,1830	do	29,552.50	
Feb. 27,1841		259,368.48	
Aug. 29,1842		24,219.83	
Mar. 3,1845	For Wabash and Lake Erie Canal	796,630.19	
May 9,1848		113,348.33	
Mar. 2,1827	State of Indiana	292,223.51	
Do	State of Illinois	285,669.11	
Aug. 29,1842	do	5,755.26	
Aug. 3,1854	State of Indiana	32,898.31	
May 24,1828	State of Ohio	438,301.32	
Do	do	499,997.12	
June 18,1838	Milwaukee and Rock River Canal Co	138,995.99	
Aug. 26,1852	State of Michigan, St. Marys Canal	749,983.06	
Mar. 3,1865	Portage Lake and Lake Superior Ship Canal Co	399,992.40	
Apr. 10,1866	Sturgeon Bay and Lake Michigan Ship Canal and Harbor Co.	199,630.98	
July 3,1866	Lac La Belle Harbor Improvement Co	100,011.67	
Total		4,590,724.79	

FOR RIVER IMPROVEMENTS.

May 23,1828	State of Alabama	400,016.19	
Aug. 8,1846	Fox and Wisconsin Improvement Co	683,302.43	
Do	State of Iowa	332,392.18	
July 12,1862	Des Moines Navigation and R. R. Co	569,382.28	
Total		1,985,593.09	

RECAPITULATION.

	Acres.	Miles.
Railroads	44,464,719.18	14,930.68
Wagon roads	2,014,084.51	1,617.70
Canals	4,590,724.79	
Rivers	1,985,596.08	
Grand total	53,055,121.56	16,548.38

FEDERAL CREDIT PARTICIPATION.

Early in this decade the Government committed itself still further to the policy of participation in transportation projects which are calculated to develop its domain and establish commerce among the people. To do this the Government has gone so far as to cross the great Pacific Ocean and stamp its approval and guaranty upon all railroads operated by steam, electric, or other power in the Philippine Islands which the Philippine government may specifically authorize, and to this end the United States has loaned its credit, and as guarantor did authorize the Philippine government to guarantee upon the responsibility of the United States the interest on all bonds issued for constructional purposes by the Philippine Railroad Company to the extent of 95 per cent of actual cost, and at 4 per cent interest for thirty years.

There is a general Federal statute permitting any railroads in the United States or her territories to cross the public domain of the United States by complying with certain regulations, and to receive from the Government a free right of way 200 feet in width. The principle of Government cooperation should apply without doubt whether the transportation agency be a railroad or a river. A river is in effect several railroads more or less in one, according to its size. The river surface constitutes the tracks and the harbor into which it empties constitutes the terminal depot. There appears to be even more reason why the Government should participate in the development of the water highways than in the arteries of commerce on land, for the one requires much less money to make them available than does the other, and therefore when completed will render their service to the people for one-sixth to one-twelfth of what the other will do.

SHARING RIVER AND HARBOR IMPROVEMENTS.

As coming more nearly to the case in hand I desire to call the attention of the Board to some of the many cases where the Government has participated with private interests or with some of the individual States or municipalities in river and harbor improvements in which there has been a duality or diversity of interest. I therefore call your thoughtful attention to the table which follows, compiled from the records of the River and Harbor Committee, covering situations where public works have been undertaken jointly by the Government and other interests, showing the amounts of the relative contributions of the Federal Government and the different interests, together with the localities and purposes thereof, covering the period from June 30, 1902, to date:

Locality.	Date.	Purpose.	Contributors.	
			United States.	Other interests.
California:				
Sacramento and Feather rivers.	1902	Restraining mining débris	$400,000.00	$400,000.00
Mokolume River	1904	Improvement above Benson Bridge	23,000.00	10,000.00
Delaware:				
Wilmington Harbor	1906	Dredging	1,005,702.00	4,857.00
Florida:				
Biscayne Bay		Dredging basin and channel from wharves at Miama to entrance.	546,000.00	Not ascertained.
Pennsylvania:				
Delaware River and New Jersey.	1905	River improvement between south State line and Philadelphia.	8,899 000.00	750,000.00

Locality.	Date.	Purpose.	Contributors.	
			United States.	Other interests.
Rhode Island:				
Pawtucket River	1907	River improvement	$501,584.00	$67,792.00
Inner Harbor at Great Salt Pond, Block Island.	1900	Excavation of ponds for inner harbor.	200,000.00	25,000.00
Entrance to Point Judith Pond.	1905	Dredging entrance channel	20,000.00	10,000.00
Tennessee:				
Mississippi River at Memphis.	1897	Repair of revetment	Not known.	750.00
Texas:				
Trinity River	1905	Construction of dams at Old River and Parsons Slough, easing bends and other improvement in section one.	643,287.00	66,000.00
Port Arthur Canal	1906	Entire improvement transferred to United States free of cost.	Not known.	Not known.
Massachusetts:				
Essex River	1907	River improvements	30,000.00	5,000.00
Michigan:				
South Haven Harbor	.....	Construction of bulkheads and establishment of dock lines.	407,900.00	.....
Minnesota:				
Fort Snelling, bridge over Mississippi River	.....	.....	125,000.00	{100,000.00 {25,000.00
Missouri:				
Missouri River at St. Joseph.	1905	River improvement (Elwood bend)	701,569.98	50,000.00
Do	1907	.....do	.....	32,500.00
Do	1907	.....do	.....	17,500.00
New Jersey:				
Cold Spring Inlet	1907	Improvement Cold Spring Inlet	1,211,000.00	100,000.00
Oregon:				
Columbia and Lower Willamette rivers below Portland.	1903 to 1907	Dredging	1,590,000.00	158,722.42
Washington:				
Upper Columbia and Snake rivers, Oregon, Washington, and Idaho.	1907	Improvement Snake River, from Riparia to its mouth.	501,544.41	125,000.00
Puget Sound and Lake Washington Canal.	1907	Canal construction	470,000.00	500,000.00

The Mississippi River affords a very instructive example of Government participation with private interests in the improvement of navigation of the Mississippi by the construction of a system of levees for the protection of commerce. In these examples of mutuality of interest and concerted purpose, it is seen that the Government and local interests participate about equally in the improvements calculated for the public good. By reference to the supplement of the annual report of the Chief of Engineers for 1904, pp. 20 to 23, the following information on this subject will be disclosed concerning levee improvements in the first and second engineer districts of the Mississippi system:

Levee districts.	Participation by local interests.	Participation by Government.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*
Upper St. Francis	283,804	377,198	661,002
Reel Foot	535,770	789,131	1,324,901
Lower St. Francis	10,071,861	5,234,111	15,249,972
Upper Yazoo	15,902,886	6,617,786	22,020,672
White River	1,633,220	6,678,495	8,311,715
Lower Yazoo	19,595,886	16,030,000	25,615,886
Upper Tensas	12,313,650	18,470,476	30,784,126
Total	60,396,527	54,187,197	114,057,724

From the Report of the Chief of Engineers referred to I quote as follows:

"It is proper to have in mind in this connection that as the riparian communities reap greater and greater advantages from the protection afforded by

the levees, they ought to contribute more and more to the expense of them. And they do. * * * The cooperation which has been maintained between the United States and the States and their local boards for the past twenty years has been a fair and cordial one, and there is no ground to claim that the local interests have not borne their fair share of the burden. For a few years to come the necessities of the situation will compel the contribution by them of all the money they can raise, notwithstanding the most liberal appropriations that can be extended from Congress."

The situation in the Muscle shoals district is parallel to what has been said on the subject of the Mississippi levees, with the exception that in this case it is proposed to tax a single class of the people of Alabama and Tennessee in meeting the cost of cooperation with the Government in establishing navigation over the shoals, instead of taxing, as would more justly be the case, all classes of the community. In this case it is the users of industrial power only who are taxed, and they are taxed through their purchase of power from the Muscle Shoals Hydro-Electric Power Company, which proposes to divide with the Government the expense of structures which are common to both navigation and power; and evidently the cost of structures to the power company will affect its charge for service to the people. Those classes of the local communities which are interested in navigation alone escape notice when the question of participation of expense in this particular improvement is discussed.

COOPERATION PROFITABLE TO GOVERNMENT WHEN POSSIBLE.

As bearing upon this general subject of the participation I call your attention to a class of projects very numerous indeed in which the Government has taken the initiative and proceeded alone and independent of other interests. Under such situations where the improvement happens to be a dam built to improve navigation, there results as a by-product of the navigation project a water power, which will have more or less value according to its location with respect to a market and its practicability. In such a case, if a person were to approach the Government in order to obtain its consent to build a water power plant, the Government surely would not present him a bill for the entire cost of their improvement done in aid of navigation, and demand that he should pay it. That would indeed by the very principle of injustice which it invokes put a veto upon the power project. The Government doubtless would say "we can not charge you a rental for the potential energy in the water, because that is not ours to claim a tribute from; that belongs to the State. We should, however, ask you to pay a portion of the expense which we have heretofore been to, for the reason that you will enjoy the use of our structures jointly with us, or we will charge you a rental for the use of our structures equivalent to an equitable share in the depreciation cost of the same and a fair interest on such portion of the investment as would be just for you to bear. That portion we should fix according to your ability to pay, and according to the relative participation in the situation as a whole which your project and navigation would enjoy."

In this connection it is evident that if the projector of a power plant could plan a use of the water independent of Government structures, he need not consult the Government at all, as long as his use of the water does not disturb navigation in any manner and the State has consented to it. So it would be at Muscle shoals, where if the Government itself were to build the dams the power-plant man could then divert the river around the structures, leaving enough water for operating the locks, and make his bargain for the privilege with the State alone. It would seem as though the Government therefore should be cooperative at a time when a profitable arrangement is offered, for undoubtedly this company could not bear even as large a share of the expense as it now proposes to do if the market which it hopes to serve were invaded by other water power transmitted in from other sources. The fact must not be lost sight of that another plant 200 miles distant would have an equal chance for a customer half way between, or 100 miles from each plant, and it would have a better chance if its cost for structures were less. The plant at Chattanooaga, for instance, at 150 miles distance, could penetrate well within the zone which Muscle shoals ought to handle, and it could do it very profitably, too, on account of having about one-sixth the length of dams that falls to the lot of Muscle shoals, with equal falls in each case. Therefore, even with the Government paying for its half of dams at Muscle shoals, the situation there would be under heavy handicap if it had to meet in competition power delivered from the new plant at Chattanooga.

I call attention to the act of Congress approved June 8, 1902, for the purpose of improving the Cumberland River. Under this act "the Secretary of War is hereby authorized in his discretion to grant leases or licenses to the highest responsible bidder for the use of the water power created by said dam at such a rate, and on such conditions, and on such periods of time as may seem to him expedient; provided that any lease or license granted shall be limited to the use of the surplus water not required for navigation, and no structure shall be built and no operations be conducted which shall in any manner injure navigation, interfere with the operations of the Government, or impair the use of any improvement made by the Government for the benefit of navigation." This is a case where the Government has acted independently in the interests of navigation, but, as yet our information is that no one has seen any advantage in applying for the water power and developing the same, although five years have elapsed—and doubtless the privilege may be obtained for a nominal annual interest charge, or even for nothing if the water could be utilized without the use of the Government structures made necessary for navigation purposes. Evidently a water power must have some commercial significance before it can be utilized.

Rather than disregard what good there is in the Tennessee, or any navigable river from a power standpoint, let it be improved for the dual purpose—let the power feature bear of the burden of cost what it can safely carry and let navigation, which is vastly far more reaching in its influence and helpfulness, vastly more profitable to the people as a whole in dollars and cents, and vastly more potent in the upbuilding of the civilization of the country, let it take the rest of the burden and carry it. This company can assert no rightful claim to the navigation feature of the river, nor can the United States assert any rightful claim to the power feature thereof.

In 1796 the United States proclaimed its sovereign control of navigation over all the navigable rivers in the country and set itself up as the people's sponsor for their guardianship and improvement under the right with which the States had endowed it. The States have never challenged that sovereignty and have relied upon the fulfillment of that stewardship. The individual State is sovereign over navigable rivers within its borders as far as all other elements in the river are concerned, such as power, irrigation, drainage, and water supply. The State of Alabama has endowed this company with all its rights of water power in the Tennessee River over the Muscle shoals and Elk River shoals, and it has exempted the company from taxation of all descriptions for ten years. It has done all it could do, and it now looks to the United States to give it navigation and at the same time chain up the wasting power for the benefit of her people. This is the psychological hour for concerted action by the Federal Government, the State of Alabama, and the power company.

INACTION NOW WILL MEAN MANY YEARS DELAY FOR BOTH NAVIGATION AND POWER.

A longer delay may spoil the opportunity for both, for as time goes on new industries are established each month, invariably connecting themselves to permanent steam plants, and the old steam plants are being rebuilt and committed to a still further use of steam. If the whole country gets fettered to steam and with new plants, the water power prospect will grow dimmer in consequence and will remain so indefinitely. Navigation on the Tennessee will likewise be threatened by the delay. The idle river will encourage the building of new railroads to usurp the opportunity which the river scorns, and then there won't be such a crying need for more transportation facilities to alleviate the congestion, and the people will pay the extreme freight for another long term of years, and the development of the Tennessee Valley will be held back for another cycle of time.

Already the Government has approved and put on the waiting list about $500,000,000 of projects for improving the rivers and harbors, which are taken up at the rate of about $20,000,000 per year. What chance within this century will the Tennessee Valley have in the face of this competition and the priorities established in other directions, if advantage is not now taken of the opportunity to cash in the power element of the river as a valuable by-product of the navigation improvements? And this opportunity, as stated before, is passing by and losing its luster with the lapse of time. Can anyone doubt the wisdom of letting the river run through water wheels and thus enable the cost of the locks and half the cost of the dams be derived from the water, rather than letting the river run to waste and benefit no one?

EQUITABLE PARTICIPATION.

We ask the Government to pay for its own purposes their portion of the joint improvement as follows:

For the locks	$1,732,000
For one-half the lands and rights	344,200
For one-half the dams	3,607,000
Total	5,683,200

It has even been suggested that we ask the Government to guarantee our bonds as it has done in connection with other public enterprises before as stated in this paper. Such a plan would certainly make power cheaper than would otherwise be possible, for with the Government credit under our bonds, they would be taken by investors at a premium instead of at a discount, so that the works would cost less and the service therefore be made cheaper. This thought is here mentioned as being akin to precedents which the Government has already established for itself, although probably outside of the scope of the inquiry intrusted to this board.

It has already been stated that it is estimated that $500,000,000 is necessary in order to carry through necessary river and harbor improvements in the United States. The Inland Waterways Commission, which in company with the President has recently made a trip through the Mississippi Valley, expects to recommend an immediate appropriation of $200,000,000, to be devoted mostly to the improvement of the internal waterways comprising the Mississippi basin. The President is in thorough accord with the programme and will lend his hearty support. As an integral and important part of this great project the Muscle shoals obstruction should not be overlooked, for it is practically the only barrier standing between the great Tennessee River Valley and the rest of the world. Mr. Burton, the illustrious chairman of the Rivers and Harbors Committee, has frequently enunciated the policy that these great improvements should be taken up in an orderly manner, and that preference should be given to such projects as are participated in by interests outside of the Central Government. There is no better example of such a class than the one under discussion, where the power company proposes to relieve the Government of over $4,000,000 of the expense as its contribution to the joint navigation and power project.

THE POWER COMPANY'S MISSION AND ITS BURDEN BEARING CAPABILITY.

The Muscle Shoals Hydro-Electric Power Company was incorporated for the specific purpose of improving the navigation of the Tennessee River over the Elk River shoals and Muscle shoals, and it can fulfill no more important public function as a part of its destiny than bringing this about in connection with the development of power at that point as its second corporate function. It asks the Government to pay for navigation features, and it therefore does not ask the privilege of levying tolls upon the commerce of the river which might ply through the ship locks incidental to the dams. No better river could be chosen for the first attention of the powers that be. Nature has given it the right direction of flow, for the trend of commerce is toward the Gulf, and later on will be through the Panama Canal. Nature has blessed this river with immunity from the plague of ice, which cripples northern rivers during the winter seasons, unfitting them not only for navigation but very often for power enterprises as well.

The power company will begin its existence without a cent of revenue and must build up from nothing to a point where it will not only pay its running cost, its depreciation and maintenance, but a fair return upon the capital invested as well. During this long period there will be running against it the interest charge on its hydraulic structures, which will be the same whether 1 horsepower is produced and sold or whether 100,000 horsepower is produced and sold. Each dam is as necessary for the development of 1 horsepower as it is for the development of 33,000 horsepower. This waiting and slow-growing process is a costly one, and will mean hard sledding for the power project, until in the course of years it has had time to establish its business throughout the country which will be tributary to it. Not so, however, with navigation, for when the dams are done the greatest commerce which the river is capable of

can immediately ply upon its surface, and the business is there to establish such a commerce. The Government from its share in the work, therefore, gets full and immediate returns from its investment, and from the standpoint of the Government, it will be an encouraging and profitable situation from its very beginning, and will multiply the value of taxable property in the Tennessee Valley.

It is hardly necessary to discourse upon the necessity of navigation on the Tenessee River as a means of relieving freight congestion on the railroads, of saving fortunes yearly in freight charges, and of developing the whole Tennessee Valley. The value of this to the people as compared to what the water power will do for them is as millions to hundreds. This company needs no ship locks. The Government does need them as a feature of its business on the river and will therefore build them at its own cost. The Government needs the dams for its business and so do we for ours. The advantage to the Government will be many fold more than what it will be to us and yet we stand ready to bear half the cost of them, and upon no less favorable basis for the power company basis can we see before us a logical, consistent, and safe water power, capable of offering a safe and reasonable investment. The fact must now be recognized that navigation as the other and more favored element of the river must bear its just share of opening up this magnificent river to the industries of the South and the commerce of the world.

We have as shown before estimated the cost of completing the navigation and power project in its entirety at $20,198,800. This is a vast sum of money, and yet it is small when a just measure of the beneficial results to be had by the people is considered. The Government's equitable portion of the bill will be as stated $5,683,200, leaving $14,515,600, or $145 per horsepower, for the power company to bear. This is the utmost that our "camel's back" can stand, even if our career is unmarred by untoward events. Any manager of power enterprises will tell you this and recommend you to be more liberal still in order to insure the commercial soundness of the enterprise. This will cut the cost of navigation improvements nearly in two, an advantage which is not usually afforded to the Government. Gentleman of the Board, it is for you to say in your wise discretion whether this project takes form or not. If we do what we offer to do we will strain our elastic limit. This power project can not stand a greater load and live. To do more would be attempting the impossible and courting disaster. Gentlemen, it can not be done.

Remember, gentlemen, this joint investment redeems an almost useless river to its fullest service to mankind. It puts a new commercial highway upon the map from Knoxville to Paducah—644 miles, and means to that country more than would a 10-track railroad. With this done the name "sixth greatest river in the United States" will then indeed mean something more than it now does.

PUBLIC OPINION REGARDING THE WATERWAYS.

Let me in closing tell you what some of the leaders in our country's affairs have to say on the subject of improving the internal waterways:

President Roosevelt in his recent address at Keokuk, October 1, 1907, said:

"I feel that we can not have too many high roads, and that in addition to the iron high roads of our railroad system we should also utilize the great river highways which have been given us by nature. From a variety of causes these highways have in many parts of the country been almost abandoned. This is not healthy. Our people, and especially the representatives of the people in the national Congress, should give their most careful attention to this subject. We should be prepared to put the nation collectively back of the movement to improve them for the nation's use. Our knowledge at this time is not such as to permit me to go into details or to say definitely just what the nation should do; but most assuredly our great navigable rivers are national assets just as much as our great seacoast harbors. Exactly as it is for the interest of all the country that our great harbors should be fitted to receive in safety the largest vessels of the merchant fleets of the world, so by deepening and otherwise our rivers should be fitted to bear their part in the movements of our mechandise; and this is especially true of the Mississippi and its tributaries, which drain the immense and prosperous region which makes in very fact the heart of our nation."

The Hon. Martin B. Madden, of Illinois, in a speech in Congress February 1, 1907, said:

"The time has come when the people of the Middle West will demand consideration at the hands of the nation's legislators. Demand it because their

claims are just; demand it because the country embraced within the Mississippi Valley is capable of producing more from its mines, fields, forests, and its farms than any other similar area in the nation; demand it because water is recognized as the cheapest transportation known to commence; demand it because the nucleus of this great waterway is already constructed and ought to be utilized."

The Hon. Robert F. Broussard, of Louisiana, in a speech before the House of Representatives February 6, 1907, said:

"This great Government of ours must open its purse to better improvement of its rivers and harbors, to the cutting of canals, even if in doing so it finds that it can spend less in armament, in colonial possessions, in strange, alien, and obnoxious government abroad with no profit to our people. This is but the beginning of the canal age. This Government of ours, the foremost nation in the race for commercial supremacy, ever mindful of the welfare of its people, must realize that we are now entering the canal age, and in order to hold our lead in the march of progress and civilization this Government's policy toward its waterways must be generous and magnanimous."

Senator Morgan said:

"The improvement of the navigation of the Mississippi River should receive the united, faithful, and liberal support of the entire country, as the most important and distinguishing feature in the commercial highways of this continent, which is without a rival in the geography of the earth. Water transportation is the great controlling power that stands for justice to the people, and they are demanding that Congress will give it rightful encouragement. There is one pronounced reason that can never be changed to support water transportation against all other methods. It is that the navigable waters belong to the people and cost nothing for construction, while all other methods belong to individuals or corporations, and the cost of transportation must be calculated at a profit on the cost of construction and ownership."

Chairman Burton in his speech before the National Rivers and Harbors Congress December 6–7, 1906, said:

"We have been spending $20,000,000 per annum on rivers and harbors, as against $100,000,000 on our Navy. I believe that there will be a change in that particular. I believe the building of light-houses and the deepening of our harbors will confer a benefit greater than that of battle ships and of bristling bayonets in making this country prosperous, great, and supreme among the nations of the earth."

From the report of the committee on resolutions of the Convention of the National Rivers and Harbors Congress December 6–7, 1907, I quote:

"Congress has demanded in the past an awakened public sentiment in favor of adequate appropriation for river and harbor improvement. We maintain the awakening has come. Congress must now recognize that public sentiment in favor of increased appropriation, as voiced by conventions and the press, has reached a point where the concern is not the advisability, but only the question of amount and frequency of such appropriation. Present conditions demonstrate that transportation facilities are totally inadequate for the prompt and economical transportation of the products of the country. Within the last ten years the tonnage moved by railroads has increased 47 per cent, while during the same period railway mileage has increased only 20 per cent. Hundreds of millions of dollars are lost annually to our farmers and other producers by the failure of the National Government to provide the assistance, which properly improved waterways will give in increased facilities for transporting freight. We maintain that water competition is the best and surest regulation of freight rates. The improvement of rivers and construction of waterways will afford the most natural, permanent and effective method of reducing and regulating the cost of transportation of both our domestic and foreign commerce."

The Hon. Joseph E. Ransdell, president of the National Rivers and Harbors Congress, said in a speech in Congress January 31, 1907:

"During the five years ending June 30, 1907, our total expenditures for all purposes of government have averaged $806,925,839.59 a year, of which sum rivers and harbors received $23,425,121.30 a year, or less than 3 per cent of the whole. During this five-year period fortifications received $6,761,489 a year, nearly 1 per cent of the whole; the Army received $80,509,481 a year, about 10 per cent of the whole; the Navy received $98,039,942 a year, about 12 per cent of the whole; and pensions received $140,857,836 a year, about 17 per cent of the whole. War and its rewards have for the past five years received every year more than 40 per cent of our total appropriations. Rivers and har-

bors received for the benefit of commerce—and bear in mind that commerce contributes practically all of our revenues—less than 4 per cent, while our Army in these piping times of peace got over 10 per cent; our Navy over 12 per cent, and our old veterans over 17 per cent. Now, I have not one word to say against the Army or the Navy, and especially against the Navy. My heart swells with a just pride when I recall the great and glorious record of our Navy without one stain upon its fair escutcheon from the days of John Paul Jones and his *Bonhomme Richard* to those of Dewey, Sampson, and Schley. And God knows I have nothing but kind thoughts and kind words for the gallant veterans of our wars. But can any fair minded man say that 3 per cent of all our revenues is a square deal for rivers and harbors? Why the Navy has received within the last five years a total of $490,190,713, almost as much in five years as rivers and harbors have gotten during the one hundred and eighteen years of our national existence.

"But would it pay to make these improvements? Yes, I say; it would pay beyond the shadow of a doubt; it would pay better than any investment this Government ever made. Why do I say this? I say it because it is a fact established beyond dispute that water transportation costs on an average in this country only one-sixth as much as transportation by rail, and whenever waterways are thoroughly improved not only does a large quantity of freight move thereon at rates only one-sixth as high as those by rail, but the rates on competing railroads are very materially reduced, and for every dollar of the people's money invested by Congress annually in the improvement of our waterways at least $2 a year are saved to the people in reduced rates.

"One thing is certain, and he who fails to see it is blind, the renaissance of waterways is at hand. The American people understand the importance and demand proper appropriation from Congress for their speedy and business like improvement. They understand that with properly improved waterways the great freight congestion which exists in every State of the Union would be relieved; and they also know that railroad rates would be regulated and reduced far better by legitimate competition on unmonopolized waterways than by any rate commission devised by man. They know that waterways were the principal and best means of transportation on earth during the tides of time until the advent of railroads a hundred years ago, and while they know that the iron horse is one of the best servants to man, and perhaps the greatest civilizer in the world, he can never supplant the waterways. I beg of you to hearken to their voice. I beg of you to make up your minds here and now to insist upon a complete and radical change in our waterway policy. Our methods have been stingy, slow and unbusinesslike in the past. Let us make them prompt, liberal, and up-to-date. Let us go at this waterway improvement as though we meant business, and do it right, regardless of cost. For the past ten years we have had an average of about $20,000,000 a year for rivers and harbors. It should not be less than $50,000,000 a year, and our votes would be applauded if we made it larger than that amount."

This same eminent gentleman, in addressing the Mississippi Valley Latin American Convention at New Orleans, April 7, 1906, said:

"The Mississippi River and its tributaries constitute the most magnificent system of internal waterways on earth. Along their shores live the dominant people of the globe. Napoleon Bonaparte, the greatest genius who ever lived, said, over a hundred years ago, that the nation which controlled the Mississippi River would be the greatest power on earth, and his words have been fully verified in the past ten years. The United States is to-day the leading power of the world. It never could have occupied this proud position but for its ownership of this mighty river. Never was there a wiser piece of statesmanship than when the immortal Jefferson made the Lousiana Purchase. He was not an expansionist and did not desire the territory of Lousiana, but he wished to make the purchase, and that purchase added a splendid empire to our domain.

"In this valley are several of our greatest cities and thousands of smaller towns. Its agricultural and mineral wealth are close seconds to its wonderful manufactures. The whole world pays tribute to it, and on its products in ocean transit to the marts of earth, the sun never sets. It was the necessity of an outlet to the sea for the people and products of this valley that caused the Louisiana purchase. Would it not be treason to neglect such a river as the Ohio? Yet it needs vast sums—possibly $60,000,000—to improve it properly, with 9 feet from Pittsburg to Cairo, and complete the development of its marvelous resource. Its main tributaries, the Tennessee and the Cumberland, are

long rivers, whose valleys teem with inexhaustible timber, mineral, agricultural and manufactured wealth, which are but in the infancy of their development—indeed, which have scarcely been touched—and the magic wand of $10,000,000 spent on each of them would open treasures to the nation and repay the Government a thousand fold for the comparatively small expense of making them navigable the year round.

"I have far more confidence in the great free highways of the Almighty, constructed by the hand of the Creator, free and open at all times, and to all men—the poorest and the richest—than I have in artificial highways constructed by men. I have far more confidence in the immutable laws of supply and demand, in the forces of competition and legitimate strife between carriers on our unmonopolized waterways, than I have in billionaire railroad trusts, regulated by a fallible and susceptible Interstate Commerce Commission of 9 or 10 men. Wherever canals, rivers, lakes and other waterways are properly developed, so that navigation is first class, freights are cheap, and there is no demand for rate regulation. This demand comes entirely from communities which have no waterways."

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY,
By CHAS. H. BAKER, *Vice-President.*

APPENDIX No. 22.

COMMERCIAL ASPECT OF THE ELK RIVER AND MUSCLE SHOALS SITUATION.

By CHAS. H. BAKER,

Vice-President Muscle Shoals Hydro-Electric Power Company.

NEW YORK, *October 29, 1907.*

To the Board of Engineers, United States Engineer Corps, appointed under an amendment to the rivers and harbors bill, second session, Fifty-ninth Congress, to examine and report on plans for improving navigation and developing power at Muscle shoals on the Tennessee River, State of Alabama.

GENTLEMEN: In our address to you of May 7 last, under the caption of "History of Muscle Shoals Hydro-Electric Power Company and what it claims," and upon page 13 thereof, upon which are enumerated our contentions which we propose to prove, I would state that in conformity with that purpose this address is directed to you for the purpose of proving contentions numbered 2d, 3d, and 5th, respectively, asserting:

(*a*) That if the entire cost of navigation improvements by slack water must be borne by the United States Government, the accomplishment of the task will be delayed many years.

(*b*) That the amount of power practicable of development at Muscle shoals has been greatly overestimated, and that if the entire cost of the necessary structures for power and navigation were to be borne by the power enterprise, it would be wholly impracticable commercially, and would remain so for an indefinite period.

(*c*) That the cost of developing the unit of power has been greatly underestimated, and the rate at which power can be sold when developed has been greatly overestimated.

So many water power developments have been financial failures, that a certain engineer, and a wag as well, has laid down this general rule as a basis for avoiding unsound investments in that line: "Halve the estimated minimum flow, then with this as a basis for horsepower capacity, double the estimated time and cost of construction, add 50 per cent for contingencies, halve the estimated revenue, and then if 10 per cent profit is apparent upon the investment, consider it safe as a 5 per cent investment." There is more truth than fiction in this. In fact, the principle involved in this rule has been so much disregarded that many water powers or roseate hue have proved monumental failures, commercially speaking, and these unfortunate examples have discredited water power securities as a class to such an extent that only a succession of notable successes will overcome it. I have in mind the plants at Sault St. Marie, and at Messena on the St. Lawrence as conspicuous examples where millions were promised and lost, and I wish to say in this connection that the Muscle Shoals Hydro-Electric Power Company has no inclination to be placed in the same

category. We have, therefore, viewed the situation laid bare of all alluring spectacular and uncertain features.

POWER CAPACITY OF THE SHOALS GENERALLY OVERESTIMATED.

I call your attention to House of Representatives document No. 761 of the Fifty-eighth Congress, second session, entitled "Water Powers of Alabama," and I refer you to page 206 of that document, upon which is given a table showing the estimated minimum net horsepower of the Tennessee River on turbine realizing 80 per cent of the theoretical power as follows:

	Fall.	Minimum net horsepower in average years.
	Feet.	
Elk River shoals	26	30,550
Muscle shoals	85	99,875
Little Muscle shoals	23	27,025
Total	134	157,450

The foregoing table is based upon the measurement of the river flow at Chattanooga 200 miles farther upstream, and drawn from a watershed of 7,500 square miles less in area than the watershed which supplies the river as it is seen flowing over the shoals as scheduled above. The above estimate of 157,450 mechanical horsepower should be added to to the extent that the 7,500 square miles additional watershed would justify. Accepting the figures, however, as stated, and making a reduction of 20 per cent to compensate for loss in the generators, step-up and step-down transformers, and transmission lines, would reduce the above total to 135,960 useful electrical horsepower. The above is then the Government's official statement of the total net electrical horsepower which could be developed and transmitted from these 3 shoals under the average low-water conditions of the river.

Whether the popular and more generally accepted estimate of the power of the stream at this point has been founded upon incompetent private investigations, or upon a roseate and exaggerated comprehension of the Government's estimate, is not known; yet nevertheless the popular estimate is as much an exaggeration of the Government's estimate as the Government's estimate is of the actual facts of the situation. The Sheffield Reaper of December 13, 1906, under the caption "The power at Muscle shoals," states the estimated horsepower of these shoals at 185,000 horsepower, which supposedly includes the Big and Little Muscle shoals, but omits the Elk River shoals; and therefore the popular estimate of the power of these shoals, upon the optimistic basis of the Sheffield Reaper, should be increased by about 25,000 horsepower to compensate for the omission of the Elk River contribution, which would make it a total of 210,000 horsepower. The Tennessee is a very broad river. There is a solemn majesty about it which appeals to the layman as he beholds it silently gliding by, but he has failed to count its depth and velocity, and therefore has no comprehension of its volume, and he knows nothing of its fall, and consequently can have no conception of its potential capacity. Neither does he take notice of the fact that he is gazing upon an average or high-water stage of the river which spellbinds him, rather than at a low-water condition which is necessarily the true measure of the river's usefulness for power purposes. The proclamation of the Sheffield Reaper may be taken as a measure of the public estimate of this water power, which simply crystallizes the enthusiasm of the local communities about the shoals, which have but little actual knowledge of the real facts of the case, where with them "the wish has become father to the thought."

However, when an individual, or a company of individuals forming a corporation, gives serious contemplation to the thought of investing money in a water-power situation, they naturally studiously eliminate any wild inferences or highly-colored guesses of the ability of a river to turn out horsepower, but instead they boil the situation down and free it of all uncertain elements in order to reach a basis where, beyond peradventure, they may know what actual output of horsepower they can get to sell and therefore what return can be gotten on their money. The most careful investor or engineer will measure the power of a river by what it will do at the lowest level of its lowest water

years. Under such a cautious consideration we are forced to reduce the popular estimate of the available capacity of the Tennessee River from the shoals in question (and when shoals are used in this paper the 3 shoals as a whole is meant) to figures very much at variance with those discussed above and varying with the weather conditions from year to year. Basing our calculations upon the recorded measurements of flow at Chattanooga between the years 1896 and 1905, we find that the shoals were capable of useful power to the extent of:

Less than—	Per cent of the time.
49,200 horsepower	1
57,400 horsepower	3
65,500 horsepower	5
73,800 horsepower	8
82,000 horsepower	12
98,400 horsepower	19

The worst years in this period were:

Year.	Less than—	Per cent of the time.
1897	41,000 horsepower	1
1899	98,400 horsepower	33
1903	73,800 horsepower	20
1903	82,000 horsepower	27
1904	49,200 horsepower	7
1904	57,400 horsepower	12
1904	65,600 horsepower	14

In other words, in round numbers, for 20 per cent of the time the power situation at the shoals will develop less than 100,000 horsepower of useful salable energy, a situation which the ultracareful investor would not seriously consider as safe and sufficient basis for establishing a 100,000-horsepower development and securing the proper returns therefrom. However, our investigation of the industrial territory which may be taken as a tributary to the shoals, displays a situation of intermittent and interweaving loads, which may favor it to a considerable extent, not only as a daily condition, but as a condition likely to obtain from week to week, or from month to month. In other words, if all the industries were to be connected with and draw their power from this one source, and the power required for their aggregate maximum demand be taken as 120,000 horsepower, it is not likely that the resultant pull would exceed 100,000 horsepower. Therefore, and in view of these conditions as we find them, and of the fact that Dam No. 3 will afford some seasonable storage, we have concluded to take the horsepower value of the shoals situation at what we would deem its safest maximum, viz, 100,000 estimated horsepower. It will thus be clear to the Board that even after accepting perhaps a too favorable view of the premises for a cautious investor to take, we find ourselves compelled to count upon from 50 to 100 per cent less power than has usually been credited to the shoals.

CONSTRUCTION COST PER HORSEPOWER GENERALLY UNDERESTIMATED.

Notwithstanding the fact that the horsepower output of the shoals, and consequently their earning capacity, can be made to vary between wide extremes, according as one takes a reckless or a safe view of the situation, yet the cost of the construction operations involving the generation of 100,000 horsepower will not differ except by insignificant margins in the minds of different investigators, and inasmuch as the construction cost per horsepower will not materially vary under different estimates, the same rule will also apply to the fixed charges, maintenance, and depreciation which will run against the investment necessary to develop such a given situation. In the matter of construction cost, as well as horsepower capacity, the shoals situation has likewise been the subject of popular error varying between wide extremes. Our esteemed champion of this project, the late Senator Morgan, actually believed that $1,000,000

would build each of the 3 dams and that $3 per horsepower per annum is a price at which a horsepower could be served to a distant customer from either of the 3 dams, a theory absurd on the face of it. "Why," said he to me, "your rock is there in the river bottom; the water is there. All you need is a little cement and the necessary labor to mix them all together and your dam is built." He overlooked the tons and tons of dynamite necessary, the heavy construction machinery, and the fact that available and efficient labor is not as handy as the rocks and water. It did not occur to him that each of these 3 dams would be a solid monolith of concrete, which would nearly fill Pennsylvania avenue in Washington from the Capitol to the White House. This country nowhere contains so large and costly a single feature of an enterprise upon which interest must be earned and paid and depreciation met.

The Senator's enthusiasm has doubtless stimulated the popular fancy, with the result that the shoals has been repeatedly proclaimed throughout the land as not only the greatest water power in the country—rivaling even Niagara—but as the one which could give the cheapest service; when as a matter of fact our investigations prove it to be a power of moderate proportions only, the most excessive in cost in the United States unless navigation participates liberally in the expense, and therefore the one which can not be looked to as commercially possible, unless navigation joins hands with it. It might be remarked at this point that the condition of the Tennessee River under which we assume 100,000 horsepower for the shoals, would, if applied to Niagara Falls, afford 3,000,000 horsepower.

If you tell an engineer that a certain power project has no tunnels, flumes nor canals, that its transmission is short, and that its cost per horsepower is much over $100, he will say immediately, "You have a dam to build, I see." If you tell him your cost per horsepower is $200 he will charge the difference all to dam, and will know that you have an unusually large one. There are three such dams necessary to develop the shoals power if only one horsepower is to be realized from each of them. It takes no more nor fewer dams to develop the entire 100,000 horsepower. One of them is something under a mile in length and the other 2 are considerably over a mile each in length. If they were each only half as long, and the investment cut in two in consequence, the power produced would be the same, as this is determined by the height of the dam rather than by its length.

We have given most careful attention to the making of our estimates of cost of this improvement, basing the same wherever possible upon our own surveys and data in order to insure a basis upon which we are willing to subscribe our estimates. Upon the basis of current prices for labor, materials, and machinery, such as an installation of this magnitude might expect to obtain, we have found that the cost of this development will be—

Development.	Horsepower delivered to customers.	Water-rights lands on river, preparation, etc.	Locks.	Dams.	Power-house substructures.
No. 1	33,400	$255,100	$575,000	$1,761,000	$602,000
No. 2	33,300	133,300	575,000	2,827,000	579,000
No. 3	33,300	300,000	582,000	2,626,000	593,000
Total	100,000	688,400	1,732,000	7,214,000	1,774,000

Development.	Buildings at dam sites, shops, power houses.	Hydraulic and generating equipment.	Transmission, etc.	Substations, including lands, buildings, and equipment.	Total.
No. 1	$169,500	$1,726,800	$1,184,800	$330,500	$3,604,700
No. 2	151,500	1,742,600	602,100	309,200	6,919,700
No. 3	151,500	1,742,600	469,300	210,000	6,674,400
Total	472,500	5,212,000	2,256,200	849,700	20,198,800

The head of water at the 3 dams contemplated by the shoals development will be practically the same at each, and since the flow of the river is the same over each dam, then the capacity at each development may be rightfully taken

as a third of the whole, although their respective costs will vary with the length of the dams. Upon the basis of 100,000 net horsepower available from the shoals at the 3 dams, and a total estimated cost of $20,198,800, the cost per horsepower of the entire development, including navigation works, will therefore be $201.98—evidently prohibitive if borne by the power company alone. Upon the more carefully considered and safe assumption of 80,000 horsepower for the entire shoals, the cost per horsepower will be $252.44 per horsepower. It will be readily seen, therefore, that upon either basis the construction cost per horsepower of the shoals project, independent of any contribution of navigation to the situation, would at once return it to where it has always been before, viz, to that class of water powers which have no commercial significance.

The shoals situation is as well known as any power possibility in the land, and has been wide open to the gaze of the world ever since hydro-electric developments began to be seriously regarded in this country. It has attracted its share of the public attention, and yet when it has drawn capitalists and engineers to it for the purpose of investigation, it has invariably repelled them from it by the unfavorable characteristics which beset it. This company has followed in the wake of at least 3 others which have failed because of lacking a true conception of the situation, and not knowing the logical method of attacking the problem. How many private and unheralded attempts were made to devise a true business aspect for the situation is not known, but it is safe to say that they were numerous. In other words, as a water-power project alone, it can not stand in the future any more than it has been able to do in the past.

Hydro-electric practice has fixed by hard experience $100 to $150 per horsepower as the cost of hydro-electric developments, including their transmission lines and substations. The cost varies, of course, according to the nature of the headworks and the distance transmitted. Power managers figure that with their power transmitted 100 miles they would be on an equality with steam power derived from Pennsylvania anthracite coal at $8 per ton. The problem would evidently be more difficult with coal around the $1 figure, as would be the case in the Muscle shoals territory. Nashville, the largest single market, is 100 miles away, and the bulk of the power would doubtless find its market at that distance. An ideal power development is that at Snoqualmie Falls, State of Washington, built by myself. Nature did so much for this project that what she left for us to do cost only about $75 per horsepower. If the above cost per horsepower is exceeded, it means a further burden of interest charge and it means an additional and more cumbersome plant to operate by virtue of being more costly in construction, and therefore most costly to operate and more sure to fail. High cost per horsepower, as in the case in hand, generally means low head and a multiplicity of slow speed units requiring more attendance and maintenance, while high-head plants involve high-speed units and fewer of them, thus meaning lower cost per horsepower, and therefore less operating and maintenance cost. Such conditions might be successfully coped with in a territory where fuels were scarce in quantity and high in price, for that would mean a compensating advantage to the project of being able to earn a high price for its product; but unfortunately this condition does not obtain in the country adjacent to Muscle shoals, but quite the contrary is true. Here we find a country where the cheapest coals exist, and coals which are highly efficient as well. Here we find the waste gases of smelters being used for making about 40 per cent of the power used in Birmingham. This is a condition of competition that can only be met by extraordinary water power, extraordinary in low cost of construction and low cost of operation.

SELLING PRICE OF POWER HAS BEEN MUCH OVERESTIMATED.

The local popular fancy has colored the shoals situation as a profitable project, which would make rich any man or set of men who might wish to undertake it. That set of men has not been found until this company, which devised the only rational project for the shoals, came into the field. It was discovered early in our investigations that power was being developed very cheaply by ordinary steam processes in the district tributary to the shoals, on account of the abundance of the cheap fuel, which will always serve as a regulator of the price of any water power served in this district. We learn, for instance, that the central station plant in Nashville by their steam plant is actually producing their power at 7 cents per kilowatt hour, which taken in connection with the

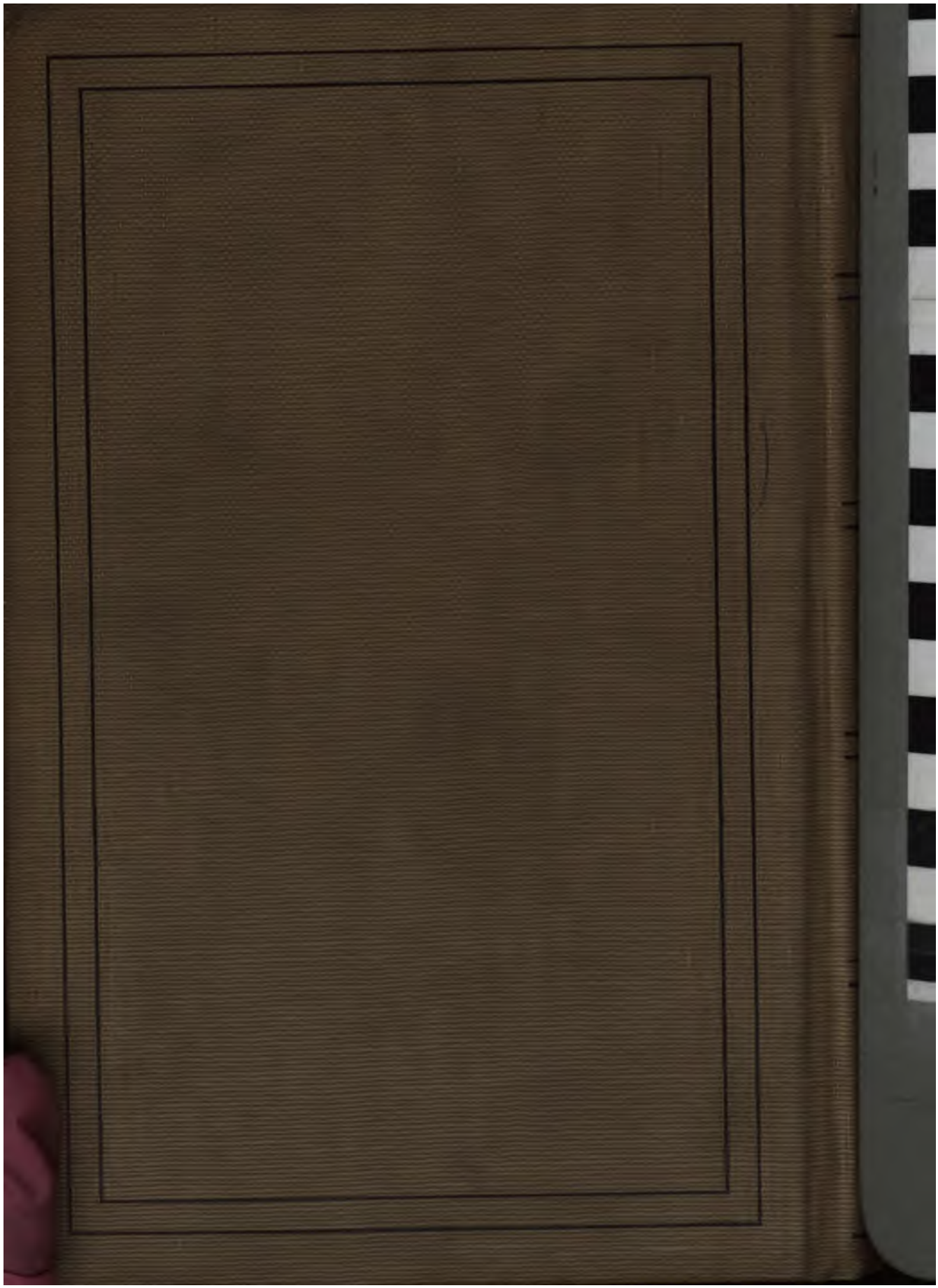
load factor on their system would make their power cost in the neighborhood of $20 per horsepower per year. Very few water-power projects are able to entertain the sale of their power at so low a figure.

Now, comes the case of a project destined to be one of the greatest and most useful to the people of this country, the manufacture of lime-nitrogen, an efficient and much needed fertilizer, having as its chief constituent nitrogen derived from air. Its other constitutents are coal and limestone, which are found in abundance in the districts not very remote from the shoals; but it is a project whose very first essential for its successful existence in America is a power at a cost of not to exceed $15 per horsepower per annum, and $15 power it must get in order to be the means of fertilizing the worn-out soils of many of the Southern States and to add to the cotton-producing capacity of the many plantations of the South. There has come also to our attention a new aluminum industry, designed to invade the field in the face of the present aluminum trust at the expiration of its patents two years hence. Within 100 miles radius of the shoals they have found all of the raw materials needful for this great industry. But there is one thing which they demand as equally needful, and that is power, not at $15 per horsepower, but at $12 per horsepower, for the new aluminum industry has to meet a rival in the open market which has fortunately possessed itself of the cheapest water powers in the country where they are making their own power at something like $8 to $10 per horsepower per year.

The cheapest fuels in the land, near at hand and very extensive, might cause this company to hesitate even after the Government's contribution in behalf of navigation of one-half of the cost of hydraulic structures common to both interests, but the company is not unmindful of a foe more worthy of its steel, and that is a foe of its own kind—other water powers. The art of insulation against high tension currents has recently been brought to so high a degree of perfection that voltages may be increased and transmissions of electricity carried to much greater distance than formerly. This will permit several low cost water powers to invade the field which this company has preempted as its own, unless this company is able to sell its power cheaply enough to discourage such invasions, or unless such other powers have sufficient attraction in size and price of market to induce them to stay at home.

This company has made a systematic canvass of the territory within a radius of transmission. It has found cotton mills in Huntsville making their own power by steam at $15 per horsepower. It has found that all cotton mills require, as a condition precedent for their existence, $15 to $20 power. The projectors of this company know from their experience in similar projects elsewhere that existing steam plants are not to be counted upon for customers unless they are broken down and ready to be rebuilt. The saving in monthly cost for power is not sufficient inducement to the owner of a steam plant to abandon it and invest in an electric motor. We must look mostly to the new industries and educate them to electric power in the beginning. It is evident therefore that the company must build up its business from nothing, although it has itself to begin life under the cost burden of a complete plant, and so must schedule deficits in the beginning of its career. It can not commence small and grow up gradually and feeling its way in safety. It must begin as an adult and take its chances in so doing, waiting patiently for that success which can only come if it has been born right.

These are the real conditions which confront the shoals situation, and Muscle shoals must be prepared to meet them, or must cease proclaiming its power producing virtues altogether. The shoals must be considered upon the basis of being able to furnish the people of the South $15 to $20 power, and such a price segregated, will give the project a fair interest return upon the investment, upon the theory that it keeps within a safe per horsepower construction cost, as mentioned before, and a reasonable margin to cover the cost of operation, maintenance, and depreciation. The industrial situation of this section of the South, therefore, demands that this water power and all others have $100 to $150 or less per horsepower as their first cost, varying according to distance of transmission and the nature of the headworks, and failing in that they cease to be water powers, commercially speaking.

Respectfully submitted.

MUSCLE SHOALS HYDRO-ELECTRIC POWER COMPANY,
By CHAS. H. BAKER,
Vice-President.